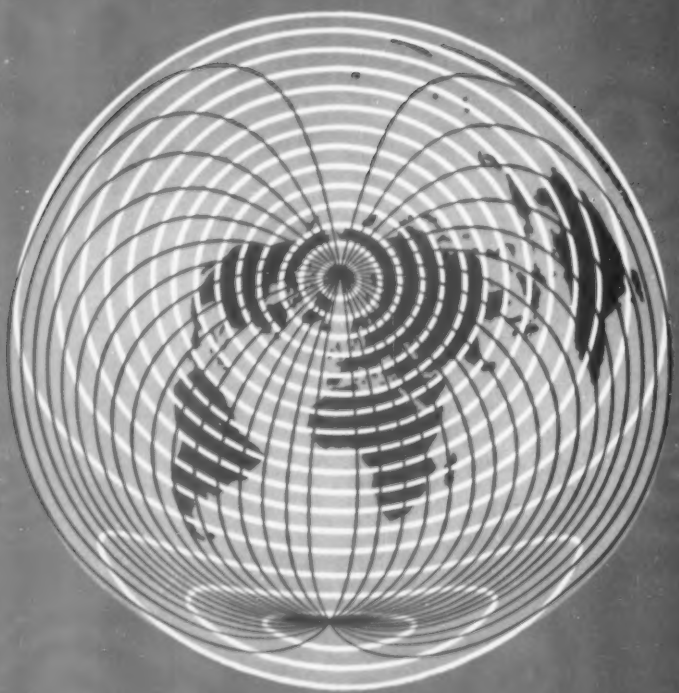
MAY 1956

TWO SHILLINGS

Wireless World

ELECTRONICS
Radio · Television



FORTY-SIXTH YEAR OF PUBLICATION

2 new Stabilised Power Supply Units

Three stabilised voltage outputs are provided by each of the two new Ediswan Power Supply Units Types R.1260 and R.1280. In each case two major D.C. outputs variable from 0 to 300v. are provided, plus a low current—D.C. output of reverse polarity.

These units are very suitable power sources for experimental electronic circuits and can frequently be used in place of several single power supplies.

Both units work from normal A.C. mains supply and are designed for standard 19" rack mounting or for bench use. Meters are included.

SPECIFICATION

Input
200-250v., 40-100 C.P.S.

Outputs
1. High stability D.C. output 0 to 300v. in one range.
   Maximum current: type R.1260 75mA
   type R.1280 150mA
2. High stability D.C. output 0 to 300v. in one range.
   Maximum current (both types) 75mA
3. High stability D.C. output -200v. non-variable.
   Maximum current (both types) 25mA

4 and 5. Two independent 6.3v. 4 amp A.C. unstabilised outputs, both centre tapped.

Notes:
A. The negative terminals of the two 300v. supplies and the positive terminal of the 200v. supply are common.

B. Either output 1 or 2 may be taken with output 3 to give a supply of 200-500v. at 25mA.

Stability
With change of mains input voltage (outputs 1, 2 and 3):
A change of 10v. in the mains supply results in an output change of less than 0.1v.
With change of load: A change from zero to full load results in output voltage changes as follows:
Outputs 1 and 2 ... Less than 0.3v.
Output 3 ... Less than 0.1v.

Output Resistance (Outputs 1, 2 and 3).
Less than 3 ohms.

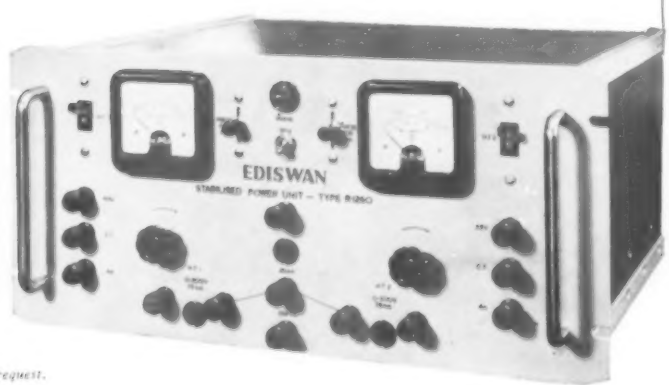
Ripple
Outputs 1 and 2 ... Less than 2mV R.M.S.
Output 3 ... Less than 4mV R.M.S.

Output Circuits
All outputs isolated from earth, and any point may be connected to earth. All terminals can be worked at up to 500 volts from earth. Outputs 1 and 2 may be switched without affecting any of the heater supplies.

Meters
Each 300v. supply has a meter which can be switched to be a voltmeter or milliammeter.

Mounting
R.1260 and R.1280 are both suitable for standard 19" rack mounting, or for bench use.

Price
R.1260—£78 nett
R.1280—£86 nett
Bench stand for R.1280—£2 nett



Further information on this and other Ediswan Stabilised Power Supply Units on request.

EDISWAN
RADIO DIVISION

SPD2

THE EDISON SWAN ELECTRIC CO. LTD., 155 CHARING CROSS ROAD, LONDON, W.C.2
Member of the A.E.I. Group of Companies.
Telephone: Gerrard 8660 Telegrams: Ediswan, Westcent, London

designed for

dependability

The "AVO" Valve Characteristic Meter, Mk. III is typical of the ingenuity of design and high standard of workmanship that exemplify all of the multi-range instruments in the wide "AVO" range.

It is a compact and comprehensive meter that will test quickly any standard receiving valve or small transmitting valve on any of its normal characteristics under conditions corresponding to a wide range of D.C. electrode voltages. The method of measuring mutual conductance ensures that the meter can deal adequately with modern T.V. receiver valves. It does many useful jobs too numerous to mention here, but a completely descriptive pamphlet is available on application.

List Price **£75** *complete with Instruction Book and Valve Data Manual.*

The AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT CO. LTD.

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SPECIALISED SOLDERING EQUIPMENT

MODELS

- 1/8 Bit (Instrument Work) List 70
- 3/16 Bit (Factory Bench Line Assembly) List 64
- 1/4 Bit (General Tagging) List 107

All Models, Solder Pot & Cable Strippers, Etc.

Manufactured to meet Voltage Supplies from 6/7v. to 230/50v.

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DETACHABLE 3/16" BIT MODEL LIST 64

For Factory Bench Line Assembly

PROTECTIVE SHIELD LIST 68

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RATING . . . . . **UP TO 2 kW**

FREQUENCY RANGE . . . . **2 Kc/s to 2 Mc/s**

H.F. power transformers of outstanding efficiency are the latest additions to the Mullard range of high quality components designed around Ferroxcube magnetic cores.

Utilising the unique characteristics of Ferroxcube to the full, Mullard H.F. transformers are smaller, lighter, and less costly than transformers using alternative core materials. These advantages are particularly marked in transformers required to handle powers of up to 2kW, between the frequency range 2kc/s to 2Mc/s.

Mullard transformers are already finding wide use in applications as diverse as ultrasonic H.F. power generators and aircraft power packs operating from an aircraft's normal A.C. supply. In the latter application, the low leakage field of Ferroxcube can eliminate the need for external screening, thereby reducing the size and weight of the transformer even further.

As with all Mullard high quality components, these H.F. power transformers are designed and built to engineers' individual specifications. Write now for details of the complete range of components available under this service.

Mullard

'Ticonal' permanent magnets
Magnadur ceramic magnets
Ferroxcube magnetic cores

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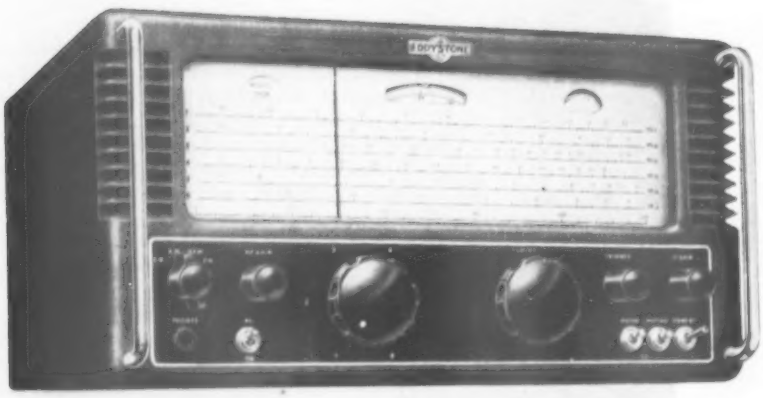
MC1A

Attention is again drawn to the EDDYSTONE 770

V·H·F & U·H·F



Communications Receivers

Specially suited for
Monitoring, Field Tests, Laboratory, Etc

for highest grade equipment

Superbly engineered and of advanced design, the two models offered possess excellent electrical characteristics and are robustly constructed for service in any climate. The "770 R" has continuous AM/FM coverage from **19 Mc/s to 165 Mc/s**; the "770 U" from **150 Mc/s to 500 Mc/s.** Both incorporate six-position turret tuning assemblies of unique design and giving high reliability. Self-contained when operated from a.c. mains and with provision for use on external power supplies. Fully descriptive literature with illustrations and performance curves available on request.

RADIO PRODUCTS EDDYSTONE TRADE MARK

Manufactured by **STRATTON & Co. Ltd., BIRMINGHAM, 31**

Master Link ..

in mobile Tele-communication

WEARITE **Vibrators**

Where the need for immediate transmission of information or instructions is of vital importance, mobile tele-communication equipment plays an increasingly important role—especially where direct contact between base and field operator, vehicle and base, or vehicle to vehicle is necessary in the interests of increased efficiency and lower operating costs.

The success of such communication over distance lies in the consistent efficiency of one component . . . the Vibrator. Without it, and its ability to withstand sustained usage and shock, mobile tele-communication cannot function.

For use where the power consumption does not exceed 30 watts, Wearite Vibrators have been specifically designed for long and dependable service, whatever the extremes of climate, and match up to the exacting requirements of the radio and electronics industry.

The main structure of a Wearite Vibrator is of steel and mica, so that expansion at varying temperature is uniform, the base being sealed by the special Wearite process. Main contacts are ground to extreme limits of flatness and consistent starting efficiency is obtained by the use of non-tarnishable precious metal driving contacts.

A complete range—synchronous, non-synchronous and split reed synchronous—is available; all are fitted with standard American bases, usually interchangeable with their equivalent type, and acoustically and electrically shielded by a sponge-rubber lined metal can. Nominal frequency is 105 cycles.

WEARITE **Vibrapower Units**

Wearite Vibrapower Units, completely self-contained, provide a supply of H.T. power from 6 or 12 volt D.C. sources, such as a large capacity accumulator. They include a tapped transformer permitting selection of output voltage, buffer capacitors and basic R.F. filtering. A synchronous (self-rectifying) Vibrator is used, type according to input voltage. Provision is made for the earth input pole to be connected to positive or negative as required. H.T. smoothing is not included and must be externally connected. Units are completely screened and mounted on rubber buffers to prevent transmission of vibration to other equipment.

Full details of Wearite Vibrator and Vibrapower Units are available on request.

Wearite vibrators are manufactured under licence from Oak Mfg. Co., Ill., U.S.A.

WRIGHT & WEAIRE LTD
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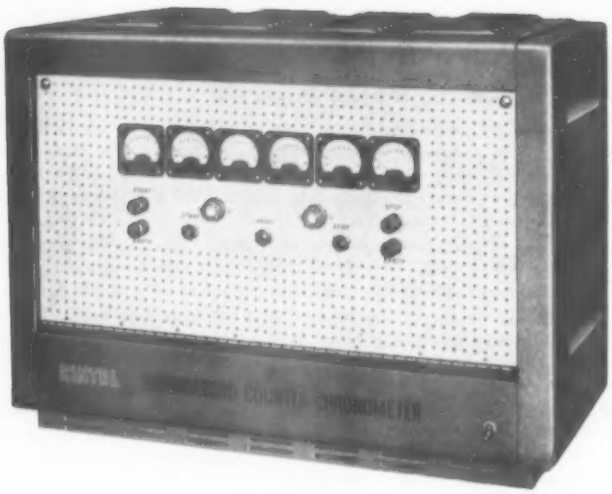
Telephone: SLOANE 2214/5 and 1510

MICROSECOND CHRONOMETER



This equipment is designed to measure small intervals of time to a high order of accuracy and two ranges are provided:

(1) 1 μsec. to 1 sec. in steps of 1 μsec.

(2) 10 μsec. to 10 sec. in steps of 10 μsec.

Accuracy of each range is better than ± 0.005% ± the step interval.

Full details on this and other 'Cintel' Chronometers are available on request.

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DC 10
PRESSURE UNIT

SPECIFICATION

Power Handling Capacity	10 watts peak
Voice Coil Impedance	15 ohms
Frequency Response	120-9000 c.p.s.
Flux Density	12,000 gauss
Pole Piece	1.5in.diameter

PRICE **£6·10·0**

Specially designed and developed to meet the need of the P.A. Engineer requiring a compact, efficient unit combining good tone with average handling capacity, at a price that will make the "small" installation a profitable proposition.

HIGH SENSITIVITY. Heavy cross-sectioned cup with latest anisotropic alloy CP magnet.

PHASE EQUALISING THROAT. One-piece zinc based alloy die-casting.

SELF-CENTRING DIAPHRAGM ASSEMBLY. Can be changed in the field without special tools or soldering iron in 1½ mins.

SPRING LOADED TERMINALS. Ensure quick and positive line termination.

WEATHERPROOF. Totally enclosed, ensuring protection when in exposed position, watertight gland cable entry.

DIMENSIONS

	DC 10 (without line trs.)	*DC 12 (with line trs.)*
Diameter	4½*in.*	4½*in.*
Length	4½*in.*	6⅜*in.*
Weight	4½*lb.*	5½*lb.*

Manufactured in Gt. Britain by

DC 12 PRESSURE UNIT (WITH TRANSFORMER)
As DC 10 but fitted with totally enclosed 100 v line transformer tapped 2·5, 5, 8 and 12 watts.
Price **£7 . 10 . 0.**

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Soldering operations are not notably glamorous — but how much depends on the efficiency and economy with which they are carried out! Always the quality and dependability of your own products. Often, in the long run, the difference between profit and loss.

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The first of the Elac
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9 x 5 Elliptical Speaker
Type 59T.
This unit is designed to give good quality at domestic volumes, it can be operated successfully in conjunction with a normally good receiver.
Where a Power Output Stage providing more than 4 watts is used, 2 or more speakers are recommended.
Flux Density, 8000 gauss (27,500 Maxwells) Frequency Response 40-12,000 Cps.
RETAIL PRICE.....38/2 inc. Tax
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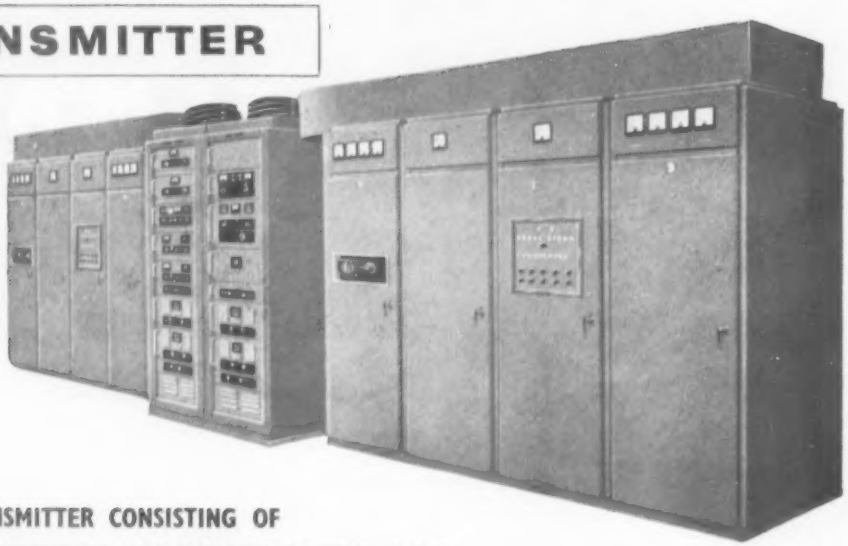
Now – MARCONI'S

IONOSPHERIC SCATTER

TRANSMITTER



40 kW TRANSMITTER CONSISTING OF TWO INDEPENDENT 20 kW AMPLIFIERS TYPE HS201 WITH FSK EXCITER TYPE HD65

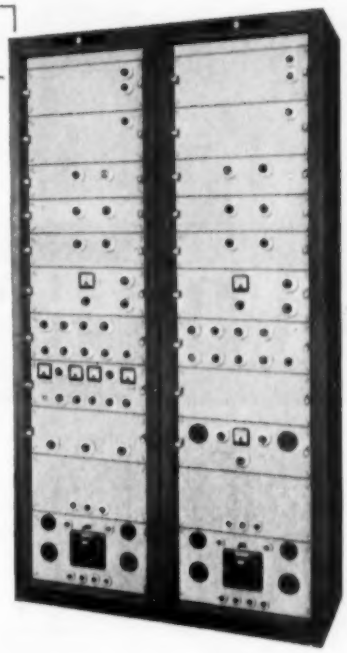
This transmitter is designed in accordance with the most advanced practice for FSK (F1) telegraphy transmission. The FSK exciter type HD65 is a separate unit; it has the essential parts duplicated, with automatic change-over to the standby equipment on failure of the working part. Facilities are included for monitoring the FSK waveforms.

- Two independent chains working individually or in parallel greatly improve the inherent reliability of the system.
- Air cooling throughout, with dust filtering.
- Double screening of power stages to reduce unwanted radiation and cooling-air noise.
- Compact assembly with safety interlocking and good access for servicing.

can announce...

IONOSPHERIC SCATTER

RECEIVER



DOUBLE-DIVERSITY RECEIVER TYPE HRI6

This receiver is designed for the reception of frequency shift telegraphy and covers the frequency range 30–60 Mc/s. It provides: pre-set crystal-controlled frequencies as required: motor-driven automatic frequency correction, reducing errors of up to 3 kc/s to less than 10 c/s mistune: a diversity-path combiner which functions on the basis of the signal-to-noise ratios of the individual paths. Full metering and monitoring facilities are built in.

Particular attention has been given to ease of servicing and all units are easily accessible.

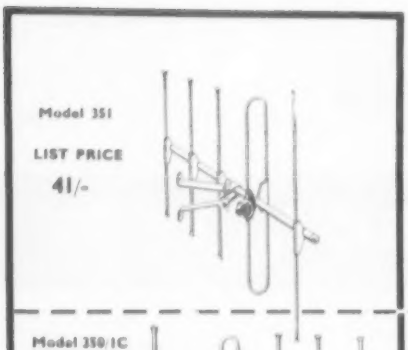
Over 80 countries now have Marconi-equipped communication systems. Many of these are still giving trouble-free service after more than 20 years in operation.

The Lifeline of Communication
is in experienced hands

MARCONI

Complete Communication Systems

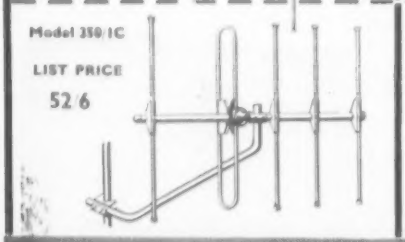
MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX



The Loft mounting models 331 and 351 are equipped with a special bracket for easy mounting in the loft and have sealed connections to enable them to be fitted to the window frame if required.

The exclusive "U" series of fully assembled Indoor Aerials have telescopic rods and rotatable adjustment to provide pinpoint reception on any Band 3 channel.

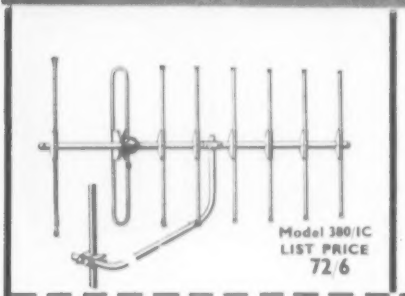
LOFT AND ROOM



3 and 5 element arrays—which have proved to be the most popular aerials for Band 3 reception in the London area—are available with three alternative mounting arrangements. Models incorporating a "U" Bolt Clamp for attachment to existing masts, as illustrated, have been outstandingly successful.

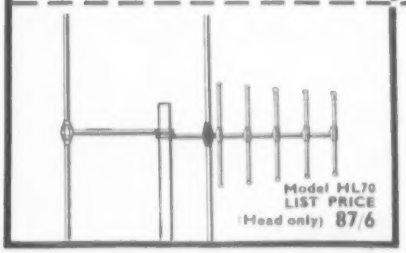
3 and 5

ANTIFERENCE FOR BAND 3



For areas where greater signal strength counts, the Antiference range contains 8 and 10 element arrays with a variety of mounting arrangements. All the exclusive Antiference design features are incorporated.

8 and 10



For Combined Band 1/Band 3 reception the HIL-O range, using our unique electronic coupling, is the complete answer in every way. Several models are available—with or without masts and mounting equipment.

HIL-O

YOU CAN RELY ON

ANTIFERENCE

☆ ***All Antiference aerials are fully covered and protected by patents or patents pending.***

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EXPERIENCE
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Wayne Kerr

INSTRUMENTS

ADMITTANCE BRIDGE TYPE B.801

1 Mc/s – 100 Mc/s

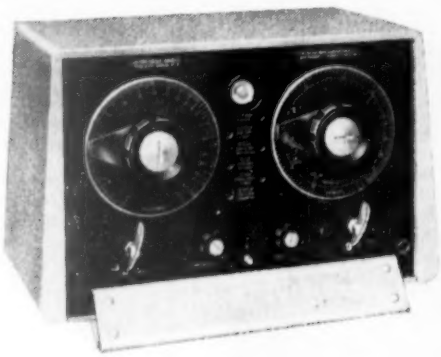
For balanced and unbalanced measurement.

Susceptance: Equivalent to ±230 pF. Accuracy: ±2%, ±0·5 pF.

Conductance: 0-100 mmho. Accuracy: ±2%, ±0·1 mmho.

This is one of a range of bridges for use with external source and detector for the measurement of aerials, cables, feeders, and a variety of components and materials between 15 kc/s and 250 Mc/s. Bridge sources and detectors are available for use between 1-100 Mc/s and 50-250 Mc/s.

PRICE £150 NET EX WORKS



COMPONENT BRIDGE TYPE B.121

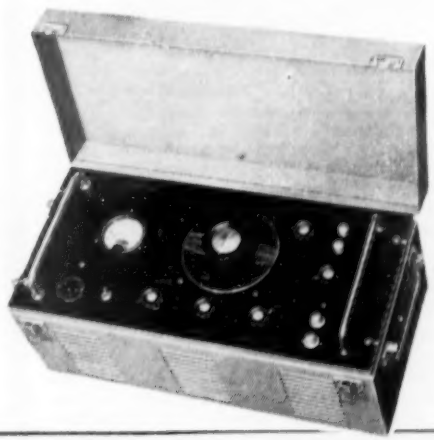
A general purpose 50 cps 3 terminal transformer ratio arm bridge for the measurement of Resistance, Capacitance and Inductance in the ranges 3-100 MΩ, 1 pF-100μF and 100 mH-10,000H, accuracy ±2%. Direct readings of the resistive and reactive components of impedance and facilities for "in situ" measurements are notable features.

PRICE £60 NET EX WORKS

AUDIO WAVEFORM ANALYSER TYPE A.321

A portable instrument to measure the relative levels of the components of a complex waveform over a range of 75 db between 50 c/s and 20 kc/s. Input impedance 100KΩ unbalanced or >25KΩ balanced. In transportable case as shown, or for standard 19" mounting.

PRICE £250 NET EX WORKS



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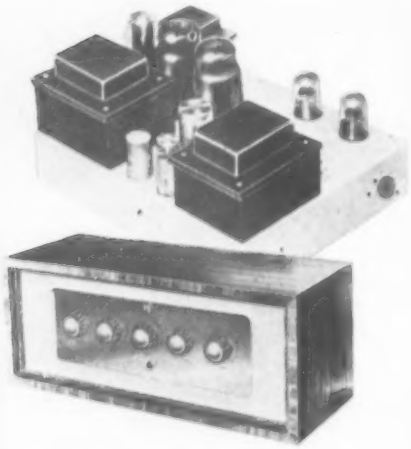
PROVOST-PROCTOR AMPLIFIER

is distinguished by these outstanding features

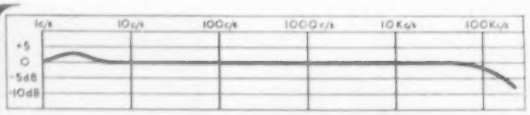


MAIN AMPLIFIER

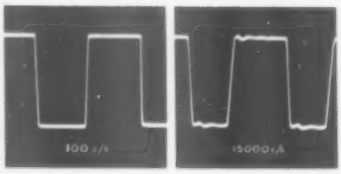
The HF25, having an undistorted output of 25 watts, provides ample power for any home High Fidelity system. Clear life-like reproduction is ensured by the low harmonic distortion and by the infinite damping factor—by this means the amplifier has complete control over the loudspeaker movement.

CONTROL UNIT

The HF25A remote control unit has phonojack inputs for radio, microphone, pick-up, tape recording and four record equalization positions for U.S. LP, European LP and R.I.A.A., U.S. 78 and European 78. The HF25A can be used up to 20 feet away from the main amplifier without loss of performance. It is available either in an attractive contemporary cabinet of walnut and sycamore veneers or in chassis form.

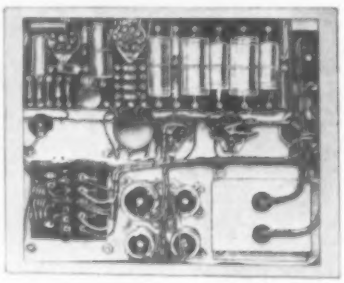


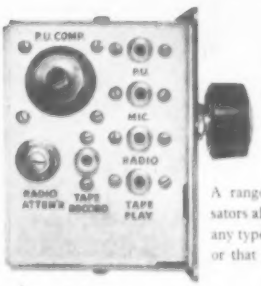
The extensive frequency range of the HF25—from 2 c.p.s. to 160,000 c.p.s.—provides 26 db of negative feedback over the entire audible range.



Square wave response at 300 c.p.s. fundamental and 15,000 c.p.s. fundamental; the latter contains harmonics to about 150,000 cycles and indicates the degree of damping attained.

The highest standard of performance and reliability is ensured by the neat chassis layout and superlative workmanship of the HF25.





A range of plug-in, pick-up compensators allows quick and easy matching of any type of pick-up either available now or that can be envisaged in the future.

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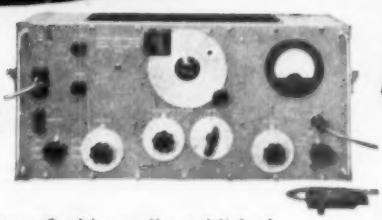
PYE LIMITED, MEXICO CITY
PYE RADIO & TELEVISION (PTY.,) LTD., JOHANNESBURG, SOUTH AFRICA

MARCONI *instruments*

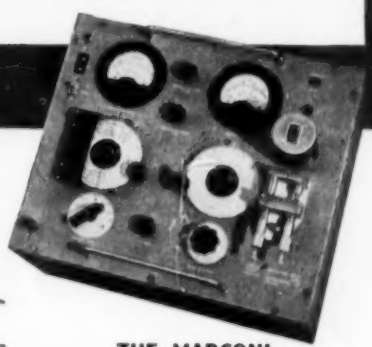
stand the test of time

Originally designed more than ten years ago! Yet the current models of the "144" and "329" are still in demand and readily available.

THE MARCONI STANDARD SIGNAL GENERATOR Type TF 144G



Nearly 6,000 instruments of this well-established series are in use, and the continuing steady demand proves that the design has withstood the test of time. The outstanding features of the latest TF 144G are:— Carrier frequency range, 85 kc/s to 25 Mc/s with alternative ranges down to 20 kc/s. Special models for use up to 70 Mc/s. Dummy aerial for receiver testing. Alternative mains/battery operation. Incremental tuning at all carrier frequencies. Output range, 1 μV to 1 volt. Amplitude modulation up to 75% depth measured by fundamental method.



THE MARCONI CIRCUIT MAGNIFICATION METER Type TF 329G

Another instrument of long standing popularity, the Marconi TF 329G is well known for its reliability and accuracy. The important attributes of the instrument are:— Magnification range, 0 to 500. Internal variable-capacitor range, 40 to 450$\mu\mu$F; provision for connecting external capacitor or special-purpose test jigs. Incremental capacitor for Q measurement by bandwith method. Internal oscillator range, 50 kc/s to 50 Mc/s; direct measurement of Q at lower frequencies by the use of an external oscillator.

The TF 329G can be used in conjuction with an a.f. oscillator to make direct measurements of Q on television line transformers at 10 kc/s, or indeed on any coils at frequencies down to 50 c/s.

Send for our booklet: **MEASUREMENTS BY Q METER**

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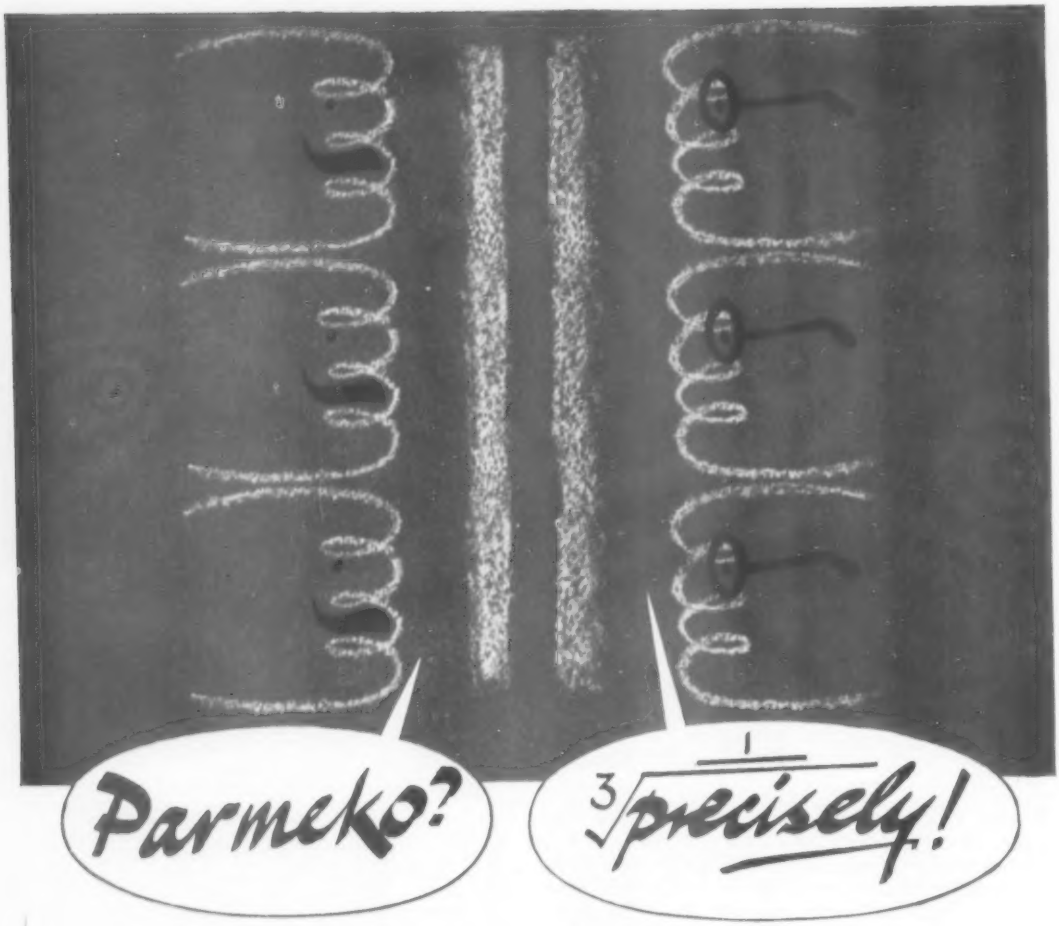
30 Albion Street, Kingston-upon-Hull, Telephone: Hull Central 16347 19 The Parade, Leamington Spa, Telephone: 1408

Managing Agents in Export: MARCONI'S WIRELESS TELEGRAPH CO., LTD., MARCONI HOUSE, STRAND LONDON, W.C.2.

TC 78



I am tempted, George, to talk of Bored Meetings or Jones, Jones & Jones in dupl. . . .

Really, old boy!

I'm sorry. I realise that this conclave must be too important to permit of frivolity but what *is* going on?

Symbolically—three-phase transformers.

But what is new about that, George?

Why, the range that Parmeko have developed to meet the growing demands made by equipment that becomes more complicated by the hour. . . .

So Industry turn to Parmeko. . . .

. . . and Parmeko turn out a new range. They're dying to tell everyone about it—why not drop them a line?

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Perfection in *miniature*

A stage in the assembly of a subminiature directly heated beam tetrode valve.

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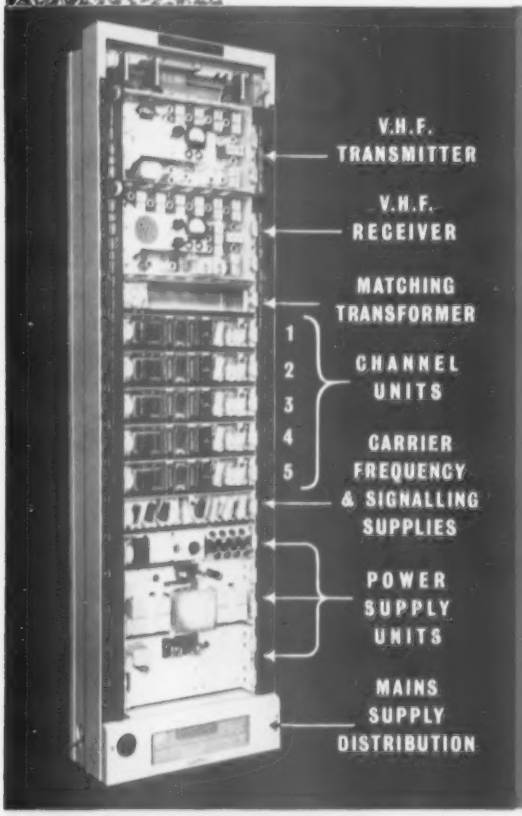

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It provides up to five circuits by frequency-division-multiplex operation over the frequency-modulated VHF radio link, and has the advantage of a narrow occupancy in the congested VHF band.
All equipment panels are of the slide-in type, easily accessible for maintenance.
Small—inexpensive—available for quick delivery.

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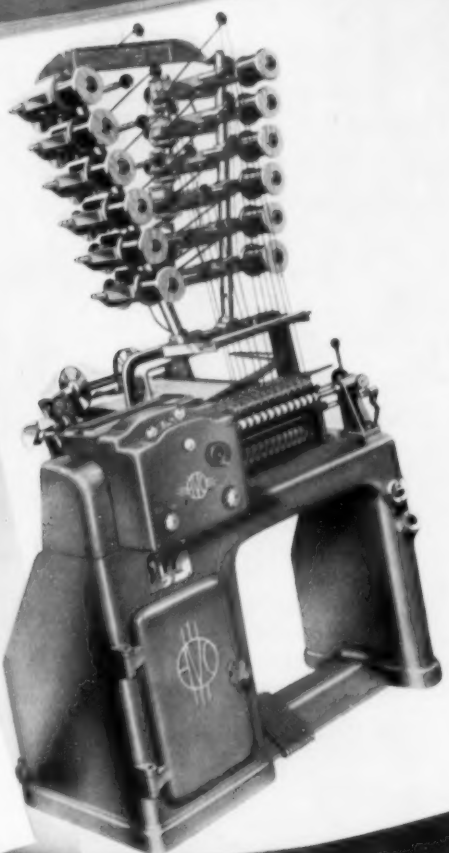
TELEPHONE RADIO AND TELEVISION WORKS—COVENTRY.

DOUGLAS AVO MACADIE

Automatic

COIL WINDERS



This typical page from our complete Catalogue shows the "Douglas" Fully Automatic Multi-Winder, designed for the high speed production of large quantities of coils with or without paper interleaving.

Our standard range includes 27 different Machines, and we make a number of other types designed for special purposes. Long experience in the design and manufacture of Coil Winders invests our machines with an unexcelled standard of efficiency and ensures maximum economy in the production of windings for every industrial requirement. Our complete illustrated Catalogue will be sent to interested executives on application.

OVERSEAS AGENTS
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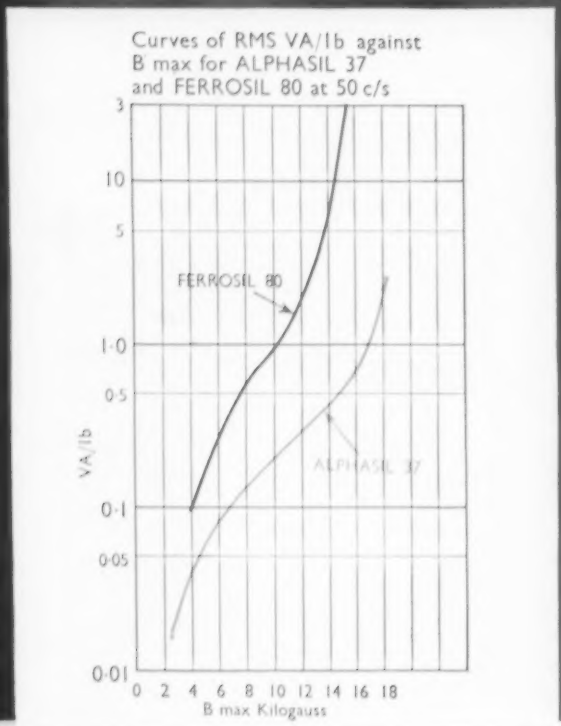

ALPHASIL

the modern core material

The inset curves show a comparison between Alphasil cold-reduced grain-oriented silicon iron and a typical hot-rolled grade (Ferrosil 80). Alphasil has a maximum permeability four times that of the hot rolled transformer sheet and its core losses are approximately one third. Initial and incremental permeability, stacking factor and ductility are considerably better than those of hot-rolled sheet.

Alphasil, ·013″ thick, is produced in sheets up to 120″ by 30″ and in coil up to 30 inches wide. Thin Alphasil, ·004″ in thickness, for high frequency work, is also available in coil up to about 4½ inches wide.

TABLE OF WATTS LOSSES

	Frequency cycles/second	Guaranteed max. total losses at B.Max 15 Kilogauss.
ALPHASIL 44	50	·62 watts/lb.
ALPHASIL 40	50	·56 watts/lb.
ALPHASIL 37	50	·51 watts/lb.
ALPHASIL 33	50	·46 watts/lb.
ALPHASIL ·004HF	400	8·00 watts/lb.

Full technical data will be supplied on request.

Above right, a 4,000-lb. Coil of 30″ wide x ·013″ thick, ready for despatch.

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incorporating the

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Patent pending

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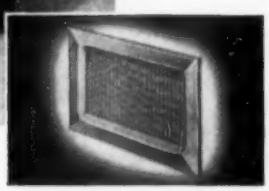

Model 172 A.R.U.	One AXIOM 22 Mk. II or One AXIOM 150 Mk. II or One AUDIOM 60 or One AUDIOM 70
Model 180 A.R.U.	One AXIOM 80
Model 280 A.R.U.	Two AXIOM 80
Model 480 A.R.U.	Four AXIOM 80

● Write now for full details of Goodmans High Fidelity Range of Loudspeakers, Axiom Enclosures and Acoustical Resistance Units.

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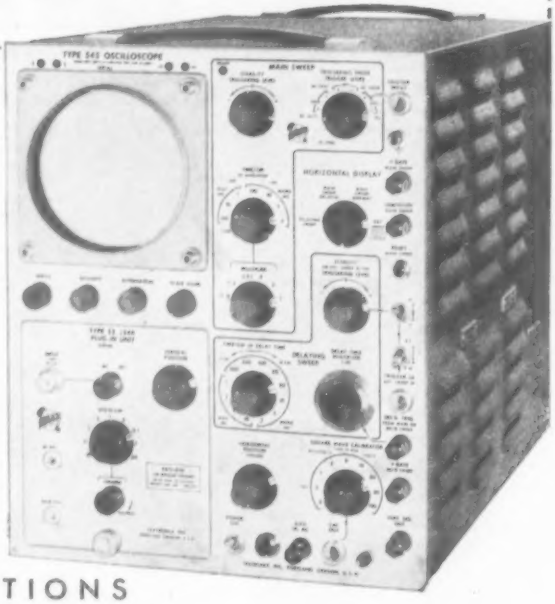
"ALL-PURPOSE" Oscilloscope...Type 545



The Tektronix Type 545 is a "fast-rise" oscilloscope with high-performance characteristics. It can write the answers to the most difficult problems in high-speed pulse analysis on its screen. You have only to read them off . . . with full assurance of their accuracy.

But the Type 545 is not a specialized instrument, useful only in fast-rise applications. It is easily adapted to a multitude of other applications by inexpensive plug-in preamplifiers. Along with its unique sweep-delay facility, this plug-in feature helps make the Type 545 the most versatile oscilloscope you ever hoped for. Is the Type 545 the answer to your instrumentation problem?

MAJOR SPECIFICATIONS

Sweep Range

0.02 μsec/cm to 12 sec/cm.
24 calibrated steps from 0.1 μsec/cm to 5 sec/cm.
24 additional calibrated steps with accurate 5x magnifier.
Calibration accuracy within 3%.

Sweep Delay

Conventional, or triggered jitter-free delay 1 μsec to 0.1 sec in 12 calibrated ranges.
Range accuracy within 1%, incremental accuracy within 0.2% of full scale.

Versatile Triggering
10-KV Accelerating Potential
Square-Wave Amplitude Calibrator
Balanced 0.2 μsec Delay Network
DC-Coupled Unblanking
Electronic Voltage Regulation

Vertical Response

With Type 53/54K Unit plugged-in — dc to 30 mc, risetime 12 millimicroseconds, sensitivity 0.05 v/cm to 20 v/cm in 9 calibrated steps, input capacitance direct — 20 μμf, with 10x probe — 8 μμf, with 50x probe — 2.5 μμf.

***Type 53/54K Fast-Rise Unit . . . . . $125 (48£)**

OTHER PLUG-IN PREAMPLIFIERS

***Type 53C Dual Trace DC Unit . . . . . $275 (106£)**

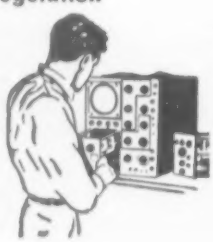
***Type 53/54D Differential High-Gain DC Unit . . . $145 (56£)**

***Type 53/54E Differential Low-Level AC Unit . . . $165 (63£)**

Prices f.o.b. Portland (Beaverton), Oregon.

*Plus duty if applicable.

***Type 545 — $1450 (558£)** plus price of desired plug-in units.



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Less than 2" x 1" max. dia.

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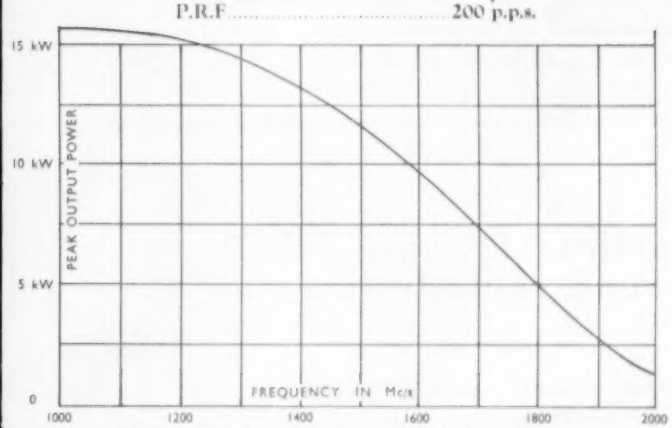
RF Output Power under PULSE Conditions

Pulse V_a ..... 4 kV
Pulse Duration ..... 2½ μsec.
P.R.F ..... 200 p.p.s.



Also suitable for use as C.W. Oscillator or Amplifier giving outputs up to 15 Watts at frequencies up to 1000 Mc/s.

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- HIGH PEAK EMISSION
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ES/T28

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The best tape recorder won't be cheap—but it will be good value for money.

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Here is the complete technical specification of the TK.820/3-D. Read it critically—and write to us if there is anything else you would like to know.

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Mains voltage: suitable for A.C. only, 105 – 115, 190 – 210, 210 – 230, 230 – 250 volts, 50 cycles. Power Consumption: approximately 90 watts maximum. Mains Fuses: 2 amps (for 105 – 115 volts), 1 amp (for 190 – 250 volts). H.T. fuses: 500 m/A Surge Resisting, 120 m/A Surge Resisting. Valve line-up: EF 86, ECC 81, EL 84, EL 42, EM 71 + 2 metal rectifiers. Mains tapping panel and fuses instantaneously available. Two tape speeds — 3¾ ins/sec and 7½ ins/sec: speed change instantaneous by electrical means – heavy duty dual speed split phase induction motor: recording time (with 1,200 feet recording tape) 2 × 30 minutes at 7½ ins/sec – 2 × 60 minutes at 3¾ ins/sec: half track recording, track change without spool reversal: track changeover by press button approximately 2 seconds. Trackbutton remains down to indicate which track was played last: frequency range 50 – 9,000 cycles at 3¾ ins/sec, 40 – 14,000 at 7½ ins/sec: noise is down at least 40 dBs and wow and flutter less than 0.3% at 7½ ins/sec, less than 0.5% at 3¾ ins/sec.

Automatic stop foil at end of spools: fast forward and fast rewind time approximately two minutes per full spool. Illuminated precision place indicator: recording level meter by 'magic eye', tone control for treble or bass emphasis.

Loudspeakers: elliptical high-flux permanent magnet moving coil + two 2½ inch tweeters. Special four-position speaker control. Connections for low impedance extension speaker and high impedance external amplifier remote controls, earphones. Microphone, diode and radio input sockets.

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Five valves — six wave bands, four with electrical band spreading. Garrard 3 speed record changer.

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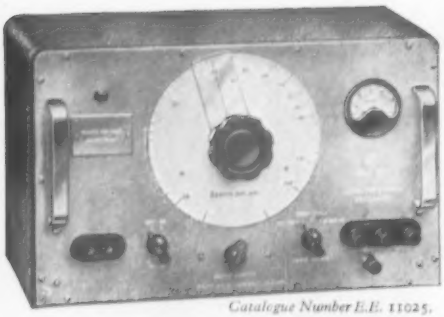

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AUDIO-FREQUENCY OSCILLATOR

This instrument employs a resistance-capacitance oscillator circuit, in which the frequency-determining elements have been carefully chosen to ensure stability of calibration. The oscillator section incorporates a control circuit which maintains the output substantially constant at all frequencies. This section is followed by an amplifier and power stage providing an output of 20 volts into an external load of 600 ohms. A surge-limiting circuit is incorporated to prevent sudden mains changes from affecting the output of the oscillator. *Please write for descriptive leaflet.*

BRIEF SPECIFICATION

Frequency Range.	20 c/s to 20 kc/s in three ranges.
Calibration Accuracy.	± 0.5 c/s up to 50 c/s. ± 1 per cent above 50 c/s.
Distortion.	Not greater than 2 % of maximum output.
Hum Level.	Not greater than 0.2 % of maximum output.
Output.	20 volts into external load of 600 ohms, balanced or unbalanced.
Mains Supply.	200-250 volts, 40-60 c/s.

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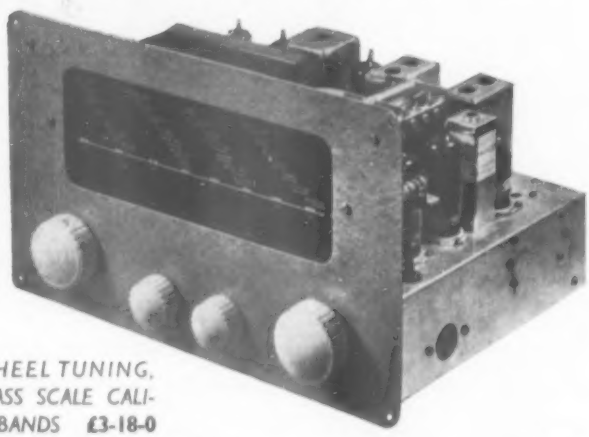

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ALL COILS INCLUDING RATIO DETECTOR, MW COILS AND TWIN IF'S **£2-17-9**

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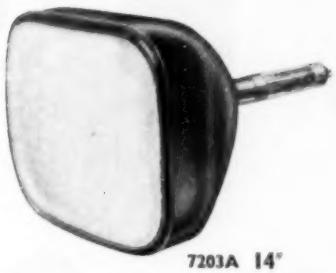

7203A 14"

G.E.C.

ALUMINISED *Cathode Ray Tubes*

- **Longer tube life.**
- **Brighter Picture.**
- **Better Contrast.**
- **Improved Daylight Viewing.**
- **Elimination of Ion Burn.**

An external conductive coating is provided. This in conjunction with the internal graphite coating forms a capacitor which may be used to provide smoothing for the E.H.T. supply.

7401A 17"

	7203A 14"	7401A 17"
Screen		
Fluorescent colour	White	White
Useful screen area	291 mm. x 218 mm.	362 mm. x 273 mm.
Picture diagonal	323 mm.	390 mm.
Scanning Angle	70°	70°
Base	B12A	B12A
Heater ratings:		
Vh	6.3V.	6.3V.
Ih	0.3A.	0.3A.
Typical Operating Conditions		
Va	14kV	16kV
Vg for cut-off	-45V to -90V	-51V to -102V
Ib	100 μA peak	100 μA peak
Modulator drive voltage	25V peak	25V peak

For further details write to the G.E.C. Valve and Electronics Department.

THE GENERAL ELECTRIC COMPANY LIMITED, MAGNET HOUSE, KINGSWAY, W.C.2

NEW ARCOLECTRIC SIGNAL LAMPS

For Low Voltage or Mains

Illustrated are a few signal lamps taken from our wide range. The insulation of every Arcolectric signal lamp will resist a flash test of 1,500 volts A.C. The S.L.90 illustrated here is a typical Arcolectric low voltage signal lampholder. It is designed to accept popular M.E.S. bulbs. The bulb is accessible from front or rear of panel. The domed plastic lens surrounded by a polished chrome bezel gives a most attractive panel appearance. This holder can be fixed in a single ¾in. hole. The mains voltage signal lamp SL88/N is supplied complete with an M.E.S. neon tube and a suitable series resistance.

Write for Catalogue No. 129

S.L.88/N

S.L.90

S.L.86

S.L.82

S.L.92

ARCOLECTRIC SWITCHES · LTD

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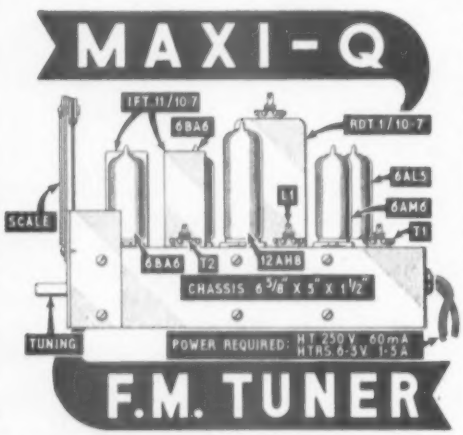

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F.M. SCALE. A bronze finished scale with yellow markings (0-20 Log) for use with all types of F.M. tuners or receivers. Consisting of metal scale, pointer, cord drive spindle, pulleys, 2½in. drum, cord and instructions for the assembly of the cord drive. The scale measures 5¼ × 3in. and is for a cabinet aperture of 4 × 1⅞in., price **9/-.**

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PDT.1/10.7 Mc/s. A miniature phase discriminator transformer for use in frequency modulation detector circuits where the limiter/Foster-Seeley type of circuit is employed. Designed for carrier deviation of ± 75 Kc/s. Qk = 1.5. Screening can 1⅞ × ⅞in. square, price **9/-.**

IFT.11/10.7 Mc/s. A miniature I.F. transformer of nominal frequency 10.7 Mc/s. The transformer is primarily intended for the I.F. stages of frequency modulation receivers and converters. The Q of each winding is 90 and the coupling critical. Dimensions as PDT.1, price **6/-.**

IFT.11/10.7/L. As IFT.11/10.7 but with secondary tap for limiter input circuits, price **6/-.**

Coil Type L1, T1, and T2. These coils are specially designed for use in the "MAXI-Q" F.M. TUNER, price **3/11** each.

Chassis and screens for the above unit, completely punched in aluminium, price **7/6.**

Obtainable from all reputable stockists or direct from works. GENERAL CATALOGUE covering technical information on full range of components, **1/-** *post free.*

DENCO (CLACTON) LTD. 357/9 Old Road, Clacton-on-Sea, Essex

STOP PRESS:

"MAXI-Q" F.M. TUNER UNIT assembled and valved at **£9/19/6** inc.

"OSRAM" F.M. TUNER completely assembled and valved at **£30/16/-** inc.

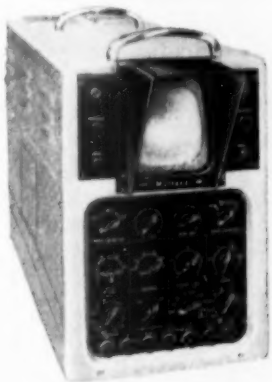
NOW dual dual trace

oscilloscope mark 2

. . . two input signals displayed for direct comparison and their characteristics accurately measured by the turn of a knob . . . such are the facilities and convenience afforded by the Mullard Dual Trace Oscilloscope, type L.101.

Well-engineered and reliable, the L.101 Oscilloscope is *the* oscilloscope where the demand is for a high grade general purpose instrument. It employs two identical amplifiers with bandwidths of 4 Mc/s irrespective of sensitivity. Each amplifier is aligned for good transient response, has a rise time of 0.1 μsec, and a maximum sensitivity of 20 mV pk-pk/cm.

The time base may be free running, synchronised or triggered. Its velocity is continuously variable between 0.1 μsec/cm and 10 msec/cm. Both time and voltage may be measured by the nul method and a well-regulated power supply preserves calibration accuracy.



mark 2 features

- **Post Deflection Acceleration** gives a brighter display at low repetition rates.
- **R.C. Probe** ensures that only negligible damping is imposed on high impedance circuits. (This probe is also available to users of the Mark 1 model.)
- **Improved Triggering Circuit** starts the time base with the minimum delay from either positive or negative signals of only 1½V amplitude.

Full details of the L.101 Mark 2 are readily available from Mullard at the address below or from any of their distributors.

Belfast: James Lowden & Co. Ltd., Tel. 57518. **Birmingham:** Gothic Electrical Supplies Ltd., Tel. CEN 5531. **Bristol:** T. Neesham & Co. Ltd., Tel. 22732. **Glasgow:** Land Speight & Co. Ltd., Tel. CEN 1082. **Manchester:** F. C. Robinson & Ptners. Ltd., Tel. Chorlton 5366. **Newcastle:** Electricals Ltd., Tel. 28517. **London:** Mullard Equipment Division, Tel. CHA 8421.

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MES89

HARTLEY-TURNER SOUND EQUIPMENT

THE HARTLEY-TURNER "315" LOUDSPEAKER

NOW AVAILABLE WITH EITHER 4 OHMS OR 15 OHMS SPECIAL COIL

The "315" Loudspeaker brings a performance normally associated with far more expensive systems within the range of most pockets. The unique construction gives results that are the closest approach to the "live" performance obtainable at a similar price.

IF YOU WANT HIGH-FIDELITY YOU NEED THE "315"

Specification	
Power Handling Capacity	15 Watts Peak AC
Flux Density	14,000 Gauss
Speech Coil Impedance	4 or 15 ohms (Please state requirements on order)
Fundamental Resonance	27 c/s
Frequency Range	25 c/s—15 Kc/s
Overall Diameter	12.1/8in.
Overall Depth	6¼in.
Nett weight	7 lbs. 8 ozs.
Packed weight	9 lbs. 9 ozs.
Chassis	Die cast non-magnetic alloy

List Price - £10 10 0

H. A. HARTLEY CO. LTD.

66, WOODHILL, WOOLWICH, LONDON, S.E.18.

Phone : Woolwich 2020. Ext. CB32

WHY ENGINEERS SPECIFY

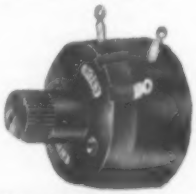
EGEN

potentiometers—

Egen Potentiometers are based on long experience of requirements of television and electronic equipment manufacturers. In design, dependability, accuracy and freedom from wear they are *outstanding*, but, above all, they are completely NOISELESS.

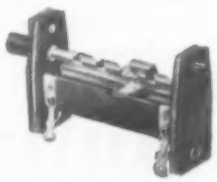
DUAL POTENTIOMETERS with concentric operating spindles. The new Egen Dual Potentiometers incorporate all these outstanding design features — multiple contact rotors, smooth easy movement, thorough screening between sections, plus a convenient soldering tag for earthing screened connections on each metal case. Switch and Potentiometer soldering tags are of high-grade brass heavily silver plated for easy soldering; they are positively located and withstand soldering heat and bending without loss of rigidity. Control spindles can be supplied to suit customers' requirements.

PRE-SET POTENTIOMETERS. Completely enclosed in high-grade phenolic mouldings. Solder tags heavily silver plated for quick soldering. Fully insulated spindles with integral control knobs. Tapped for 2-hole 6 B.A. fixing on 1" centres. Type 126, wire-wound. Type 127, carbon.



STANDARD CARBON POTENTIOMETERS. Made by an entirely new method ensuring a highly stable resistance element, which is also very durable. Silent and smooth in operation, these controls offer both mechanical and electrical reliability. Soldering tags are heavily silver plated to resist oxidisation, and the mains switch has an efficient quick make-and-break action.

PRE-SET RESISTOR. This has a wire-wound resistance element, traversed by a nickel-silver slider. Adjustment is effected by a worm drive spindle fitted with a knurled and slotted knob. This component is smooth and noiseless in action and is designed to meet the many and varied requirements of the Electronic Industry. Egen pre-set resistors can be supplied in multi-bank assemblies to suit individual requirements. There are also twin-track models, and types with an electrically divided slider, giving adjustment on two resistors with one operation.



EGEN ELECTRIC LTD. Charfleet Industrial Estate, Canvey Island, Essex · Phone: Canvey Island 691/2

For vivid lifelike sound—

Expert recordists and sound technicians all over the world prefer 3M magnetic recording tapes, especially for high-precision recording of vocal, instrumental, or mechanical sound.

YOU PAY NO EXTRA FOR THE SUPERIOR QUALITY OF 'SCOTCH BOY'

For faithfulness and clarity, and freedom from background noise, make your recordings on 'SCOTCH BOY'. This tape has an unrivalled reputation in research laboratories, when the success of vital experiments depends on the precise measurement and reproduction of sound.

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SPECIALIZE
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enables the deaf to hear TV and Radio programmes in comfort and safety and with a clarity unobtainable when using a hearing aid for this purpose. It is also ideal for those with normal hearing who wish to hear the programmes without disturbing others.

The Adaphone has an attractive grey plastic case (3in. x 2in. x 1¼in.). Weighted straps hold it in position on any chair arm. The input is matched for 2 to 10 ohms connection and the transformer tested to withstand 2,000 volts D.C. The listener can adjust the volume to his individual need without affecting the loudspeaker volume.

Tone control is obtained by alternative output sockets: 'Normal' and 'High.'

The M3 model has Automatic Volume Compression.

A low-impedance insert-type magnetic miniature receiver of D.C. resistance 30-40 ohms is supplied, but a bone-conduction receiver is available instead, at extra cost, for those who prefer it.

MODEL M4. Complete with miniature earpiece, standard earmould, and leads	£4 19 0
MODEL M3. Incorporating Automatic Volume Compression, complete as above	£5 15 0
MODEL M5. Incorporating Loudspeaker Switch for 'silent' listening	£5 15 0

Obtainable through all leading Radio Dealers or direct from Multitone Electric Company Limited.

Inquiries should be addressed to

MULTITONE ELECTRIC CO. LTD.
223-227 St. John Street, London, E.C.1.
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ELECTRONIC MINIATURES

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The Finger-Tip VOLUME CONTROL

Diameter (A) .680" (17·3 mm.).
Thickness (B) .170" (4·3 mm.).
Length of Contact (C) .110" (2·8 mm.).

The miniature finger-tip Volume Control is widely used in small radios, hearing aids and electronic equipment as a dust-sealed potentiometer or volume control.

Its unique construction, with bearing surfaces at the periphery, ensures that rotation of the control is wobble-free. The side plates, which do not rotate, are slightly proud of the peripheral rotating ring, enabling the control to fit tightly in any slot without fouling when turned.

Semi-logarithmic and linear laws are available in all values between 5KΩ and 3MΩ; in addition, logarithmic laws are available in all values above 10KΩ up to 3MΩ.

Life-tests (at 30 complete cycles per minute) up to 30,000 cycles on production samples, plus rigid mechanical and electrical tests of each individual unit, guarantee a reliable product.

THE SUB-MINIATURE TRANSISTOR TRANSFORMER
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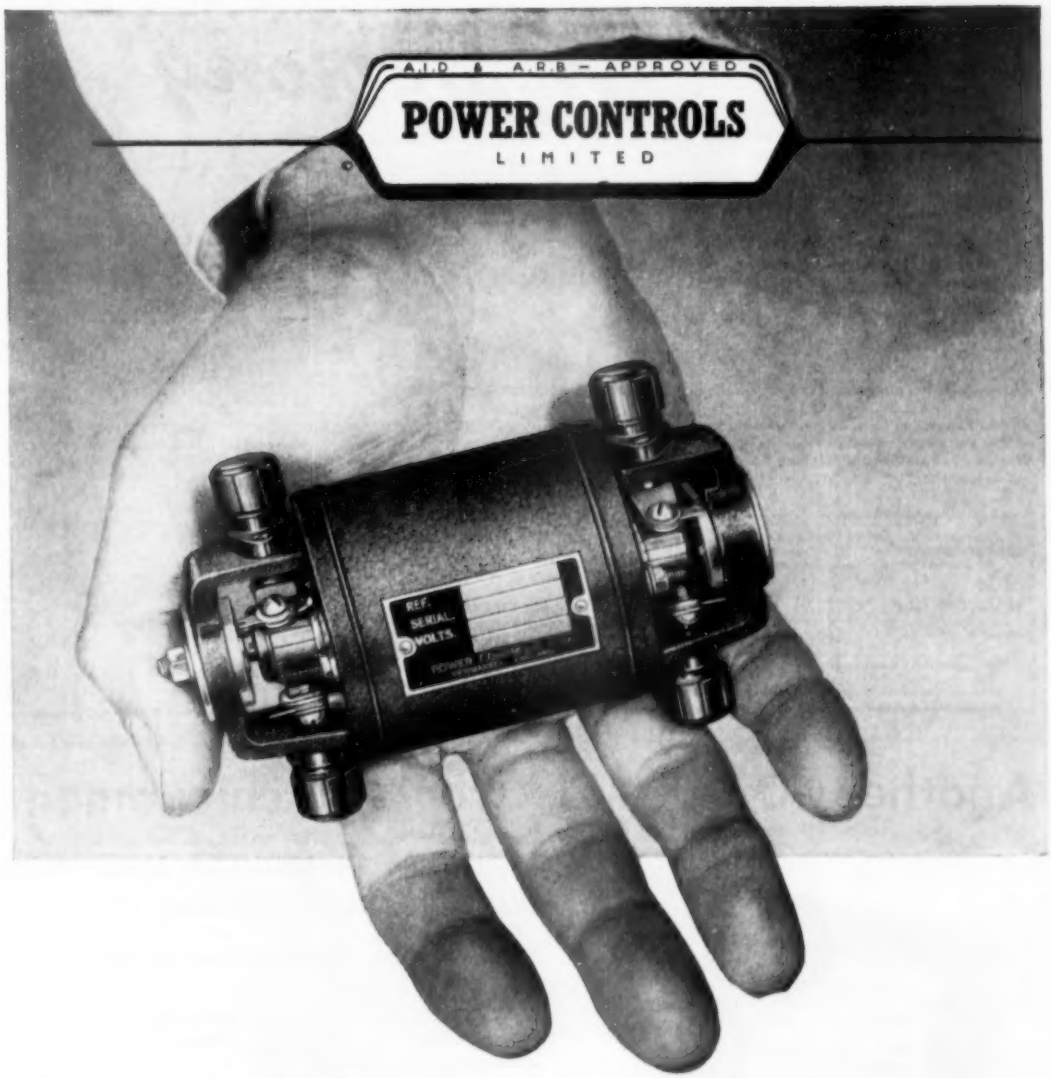
Details on request to

ARDENTE ACOUSTIC LABORATORIES LTD.
Springfield Works, Horn Lane, Acton, London W.3
Telephone: ACOrn 4161-1282



Rotary Transformers

Have you a transformer problem? If so, we can help you. We can undertake to develop and manufacture rotary transformers to your specification.

The illustration shows a typical transformer which we are manufacturing for a specific requirement. Made for 6, 12 or 24 volts D.C. input, it can supply a continuous D.C. output of 350 volts at 30 mA. or an intermittent output of 310 volts at 60 mA. The no-load current consumption is 2.2 amps. at 11.5 volts and the ripple voltage is less than 6 volts r.m.s. on 60 mA. load. The size is only 4-9/16" long by 2-21/32" across the brush terminals.

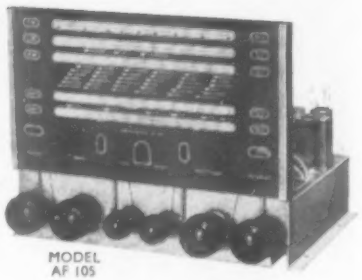
Power Controls Ltd., Exning Road, Newmarket, Suffolk

Telephone: Newmarket 3181. Telegrams: Powercon, Newmarket

WE HAVE DEVELOPED THE AF 105 to meet the needs of those who require high quality radio and record reproduction but who, for reason of expense, or lack of room in existing or proposed cabinets, cannot consider the separate units (Amplifier, Control Unit, AM and FM Feeders) of the normal high-fidelity system. The AF 105 combines all these on one compact chassis, and its performance is as good as, or better than, all but the most expensive Amplifier and Associated units.

Armstrong 105

Three-in-one Radiogram Chassis



MODEL AF 105

AM and FM Tuners and High Fidelity Amplifier on one compact chassis

We shall be glad to give you a full demonstration of this and other models in our Range at our Warlters Road showroom (Open 9-6 weekdays and Saturdays).

Post this coupon for descriptive literature and details of Hire Purchase, Home Trial facilities and Guarantee to Armstrong Wireless and Television Co. Ltd., Warlters Road, London, N.7. Tel: NORth 3213.

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AMPLIFIER

Output: 10 *watts, push-pull.*
Frequency Range: 15-35,000 C.P.S. ± 1dB.
Negative Feedback: 20 dB, 15-20,000 C.P.S. *(Over three stages).*
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Coverage: 86-102 *MC/S.*
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MODEL A.F. 105

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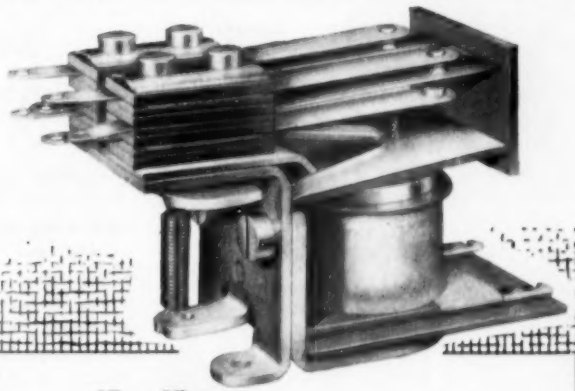
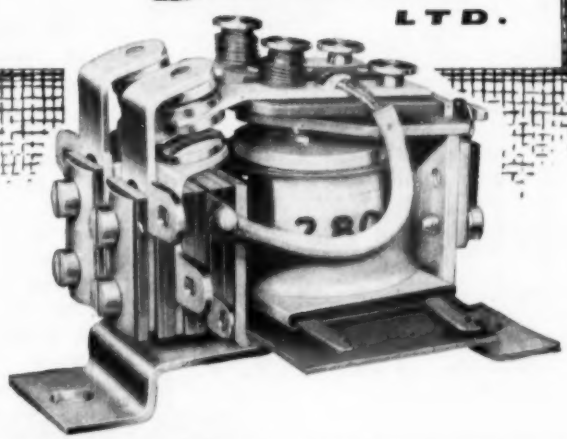
When it's **RELAYS** contact



Magnetic Devices LTD.



Upper illustration: Series 100 a.c. operated; Series 105 d.c. operated. Contact ratings up to 10 amps. continuous. Switching: one to six poles in various combinations. Overall size: 2¾" long by 1¼" wide by 1¾" deep.

Lower illustration: Series 151 a.c. operated; Series 156 d.c. operated. Contact ratings up to 15 amps continuous. Switching: double pole change-over or double pole single throw. Overall size: 2⅛" long by 1⅝" wide by 1⅝" deep.

Coils are wound for standard voltages up to 250V. A.C. and 140V. D.C. Consumption is 3 watts D.C. or 6 V.A., A.C. Coils can be supplied vacuum impregnated.

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Magnetic Devices LTD.

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Amplifiers (complete)	£ s d		£ s d		£ s d
Acoustical Quad Mk. II	42 0 0	103/1	21 0 0	38/11	42 0 0
Leak TL10 and Point One	28 7 0	73/10	14 3 6	26/3	28 7 0
Rogers RD Junior	26 0 0	63/7	13 0 0	24/2	26 0 0
W.B. 12 Hi-Fi	25 0 0	61/1	12 10 0	23/4	25 0 0
E.A.R. Mullard 510	18 18 0	46/5	9 9 0	18/3	18 18 0
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Wharfedale W15CS	17 10 0	42/9	8 15 0	17/1	17 10 0
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„ Golden 10	8 0 11	21/3	4 0 6	9/2	5 15 0
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G.E.C. Metal Cone	9 10 0	24/6	4 15 0	10/5	6 10 0
Goodmans 150 Mk. II	10 15 9	27/4	5 8 0	11/6	10 15 9
„ Axiom 80	24 4 9	59/3	12 2 6	22/8	17 10 0
„ Audiom 60	9 2 9	23/8	4 11 6	10/1	9 2 9
„ Axiom 22	15 9 0	35/6	7 14 6	15/4	15 9 0
„ Axiom 102	10 7 9	26/5	5 4 0	11/2	7 10 0
Tuner and Radio Chassis					
Chapman S6 or S5Export	22 8 0	54/9	11 4 0	21/2	16 0 0
„ S6BS (Handspread)	46 4 0	112/8	23 2 0	42/10	33 0 0
„ S5 or S5E (F.M.)	34 2 6	83/5	17 1 3	31/7	24 7 6
„ F.M.81 Mk. II	22 1 6	54/-	11 0 6	20/10	15 15 0
„ F.M.82 (powered)	25 4 0	61/11	12 12 0	23/6	18 0 0
R.G.1 8 valve R'gram Chassis	23 2 0	51/4	11 11 0	19/3	17 10 0
Gramophone Motor Units					
Garrard RC110 Changer	14 13 3	35/11	7 7 0	14/9	10 11 0
Garrard RC80M	18 6 8	44/9	9 3 4	17/9	13 3 9
Collaro RC54 Changer	13 17 0	34/1	6 18 6	14/-	10 0 0
„ 2010 and Pickup (T)	19 10 0	47/8	9 15 0	18/11	14 1 6
„ 2010 less Pickup (T)	14 18 0	36/5	7 9 0	14/11	10 15 0
Connoisseur Variable (T)	28 11 4	69/10	14 5 8	26/6	20 0 0
Garrard 301 (T)	25 8 2	66/7	13 4 1	24/6	19 0 0
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Decca X.M.S. (complete)	6 15 7	18/5	3 7 10	8/2	4 17 6
Acos GP20/19 (complete)	5 14 0	16/-	2 17 0	7/3	4 5 6
Connoisseur Diamond Styli	23 1 0	56/4	11 10 6	21/8	16 3 0
„ Sapphire Styli	10 15 7	27/4	5 7 10	11/6	7 11 0
Leak Diamond and Transformer	21 19 9	53/9	11 0 0	20/10	16 0 0
Tape Recorders and Decks					
Editor 2-speed Standard L.P. Tape	50 8 0	123/3	25 4 0	46/8	50 8 0
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Truvox Mk. IIIU Deck	23 2 0	56/5	11 11 0	21/9	23 2 0
Lane Mk. VI Deck	18 10 0	45/3	9 5 0	17/11	18 10 0
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Acos Mic-16 (30/10,000)	12 12 0	31/4	6 6 0	13/-	12 12 0
Lustraphone VR53 Ribbon	10 10 0	26/8	5 5 0	11/3	10 10 0
„ LFV Tubular Dynamic	8 18 6	23/2	4 9 3	9/11	8 18 6
Microphones (Ronette)					
MADE IN HOLLAND—					
RFC Studio	8 15 0	22/9	4 7 6	9/9	8 15 0
„ „ low impedance	10 10 0	26/8	5 5 0	11/3	10 10 0
R572 Twin Microcell	9 19 6	25/6	5 0 0	10/10	9 19 6
R572L ditto low impedance	11 19 6	29/11	6 0 0	12/6	11 19 6
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„ TK12	73 10 0	179/8	36 15 0	68/2	73 10 0
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„ Stenorette	38 17 0	95/-	19 8 6	36/-	38 17 0

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We detail on left a further selection of Equipment available to you on various methods of easy purchase, that is, by Credit Sale Agreement, providing for nine equal monthly payments, with the equipment despatched to you upon receipt of the first payment; or by Hire Purchase terms with the equipment despatched to you after receipt of the initial deposit, followed by twelve monthly payments. For equipment over £50 in value, this period can be extended up to eighteen months.

We are also detailing our export prices. For easy import facilities and regulations we have classified this selection of equipment into its country of origin.

Please include carriage and packing sufficient for your order when sending your initial deposit. Our charges for service are kept very low, and we have an unrivalled stock of high fidelity Audio equipment. Tape Recorders, ancillary equipment and domestic radio, Radiograms, and television receivers.

If you do not see the item in which you are interested in this list, please send S.A.E. mentioning your needs, for full details by return.

E. & G **MAIL ORDER SUPPLY CO.**

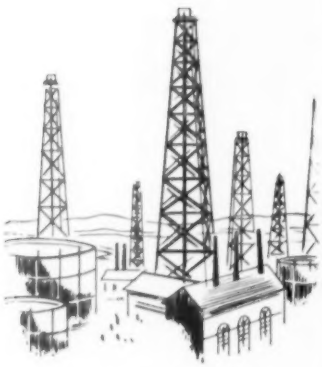
The Radio Centre

33 Tottenham Court Road : London : W.1 : Tel: MUS 6667

M·O·S

Redifon GR 164

5 WATT H.F. TRANSMITTER-RECEIVER



for use in undeveloped territories

Ideal for police, armed services, meteorological services and oil companies in undeveloped territories, the compact low power Redifon GR. 164 is very suitable for point to point and fixed to mobile communications over short distances where the terrain is unsuitable for V.H.F. Vehicle mounted or portable, it is supplied with A/C mains pack, 12 volts D.C pack, or pedal generator. It is extremely simple to operate.

Radio Communications Division
REDIFON LIMITED, BROOMHILL ROAD, LONDON, S.W.18. VANdyke 7281
A Manufacturing Company in the Rediffusion Group

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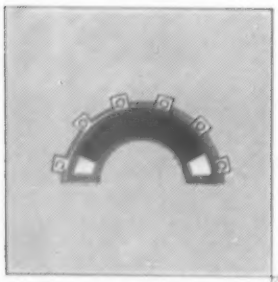
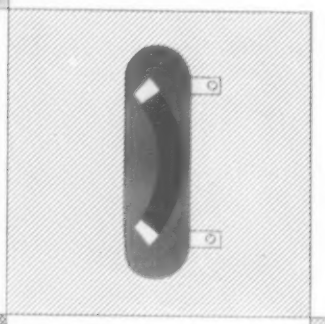
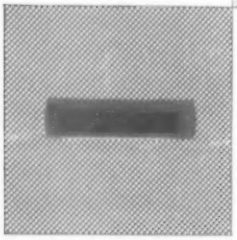
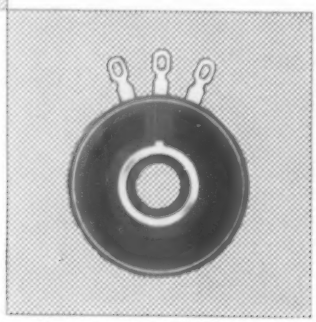


Precision Resistive Elements







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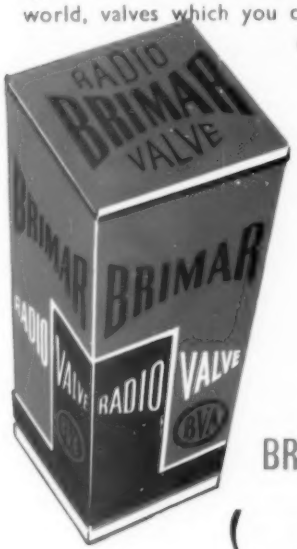

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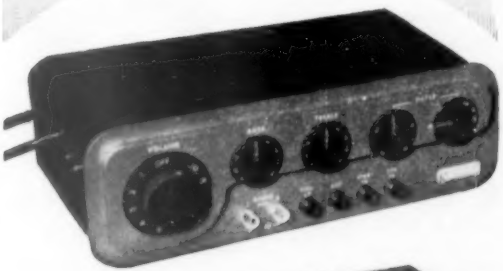

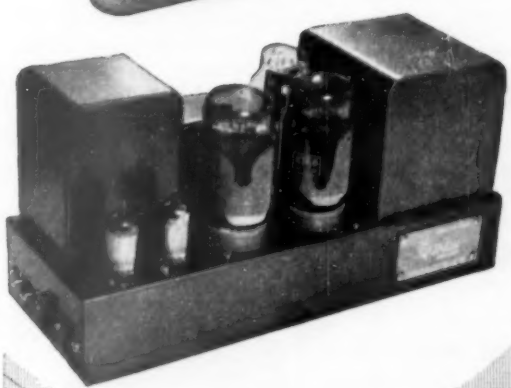

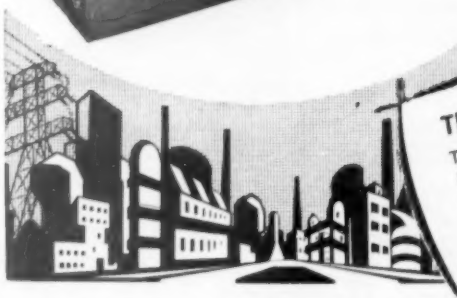

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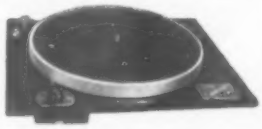

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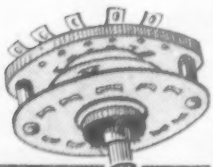

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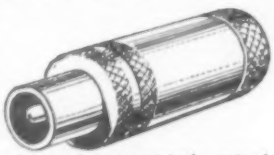

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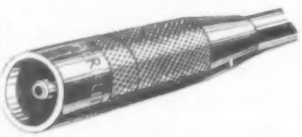

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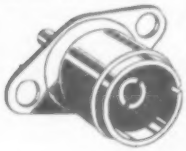

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This type of installation has never been done in any theatre here and although theoretically it was quite sound, one cannot help that uncertain feeling until the equipment is actually in use. However the show has now been running for over two months and our installation has created a great amount of interest. You will no doubt be interested to hear that Mr. F. Langford-Smith, editor of "Radiotronics", referred to our installation as one of the best he has ever heard.

I might add that the two outside microphones are placed on the far corners of the stage with one in the centre, which gives the audience a completely stereophonic effect. Apart from being able to understand the quietest word spoken on the stage one is not aware of any amplification. The system does however create an amazing sense of presence, felt in every part of the theatre.

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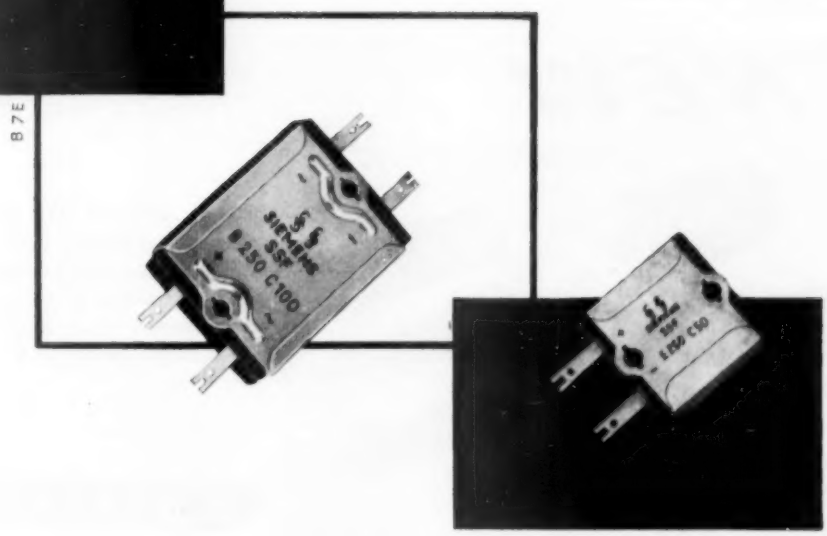

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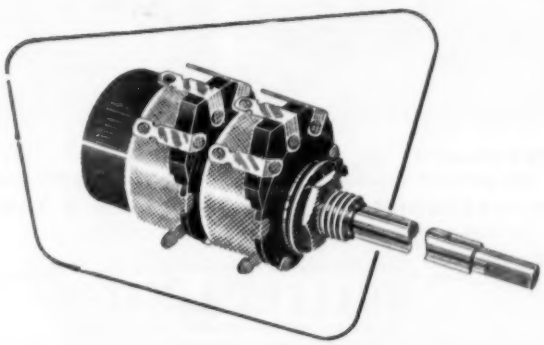

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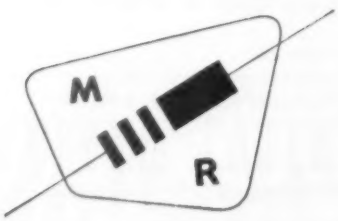

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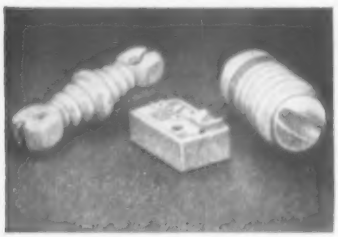

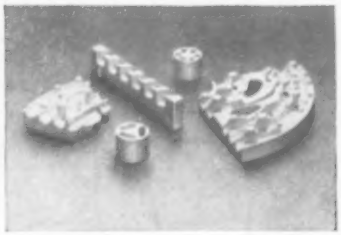

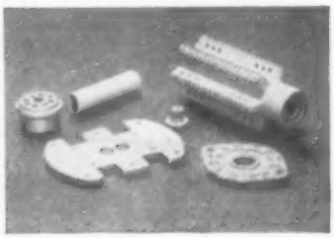

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..in the matter of electronics

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ELECTRICAL REVIEW

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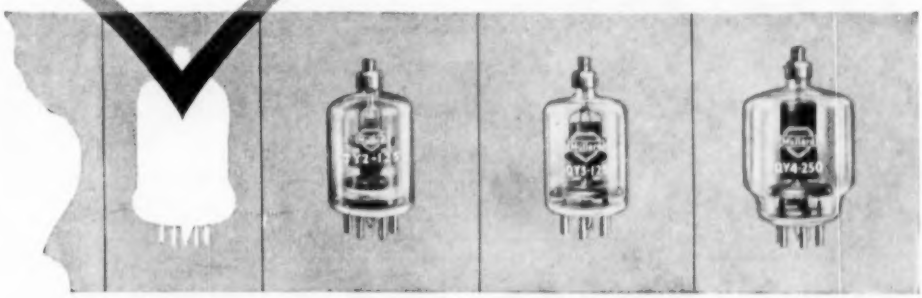
DORSET HOUSE, STAMFORD STREET, LONDON, S.E.1.

QY3-65

V.H.F. POWER TETRODE

a new addition to a popular range



This new tetrode, the QY3-65, embodies a similar technique and construction to the Mullard range of all-glass transmitting valves which are already well established in communications and industry. It has an anode dissipation of 65 watts and a maximum frequency of 250 Mc/s and is directly interchangeable with the American 4-65A.

Relatively high outputs can be obtained from the QY3-65 at low anode voltages, and its quick heating filament allows power consumption during standby to be reduced to a minimum.

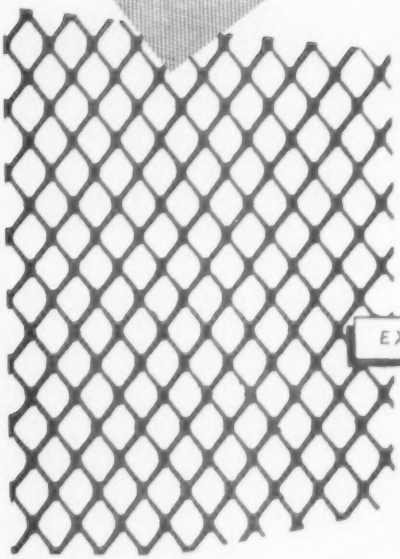
Write for detailed information on this valve, power triodes and other tetrodes made by Mullard.

MAXIMUM OPERATING CONDITIONS (CLASS C AMPLIFIER) AT 50 Mc/s									Maximum frequency at reduced ratings (Mc/s)
Valve	Type	V_a (V)	V_{g1} (V)	I_a (mA)	I_{g1} (mA)	V_{in} (peak) (V)	P_{load} (W)	%	
QY3-65 (CV1905)	**TETRODE**	**3000**	**-100**	**115**	**10**	**170**	**224**	**81**	**250**
TY2-125 (CV1924)	TRIODE	2500	-200	205	40	390	310	76	200
QY3-125 (CV2130)	TETRODE	3000	-150	167	6.5	300	300	75	200
QY4-250 (CV2131)	TETRODE	4000	-225	312	9	374	800	80	120

Mullard MULLARD LTD., COMMUNICATIONS & INDUSTRIAL VALVE DEPT., CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, WC2

MVT184

EXPANDED Tantalum Mesh



EXPANDED TANTALUM MESH can be supplied by Murex Ltd. in 60, 42 and 30 mesh per linear inch. The overall thickness of the mesh can be between ·004″ and ·007″ for the 60 mesh, from ·004″ to ·015″ for the 42 mesh and ·007″ to ·015″ for the 30 mesh. The maximum width of piece which can be supplied is 5·9″. The material can be supplied either as expanded or can be flattened after expansion.

EXAMPLES OF MESH MAGNIFIED 10 TIMES

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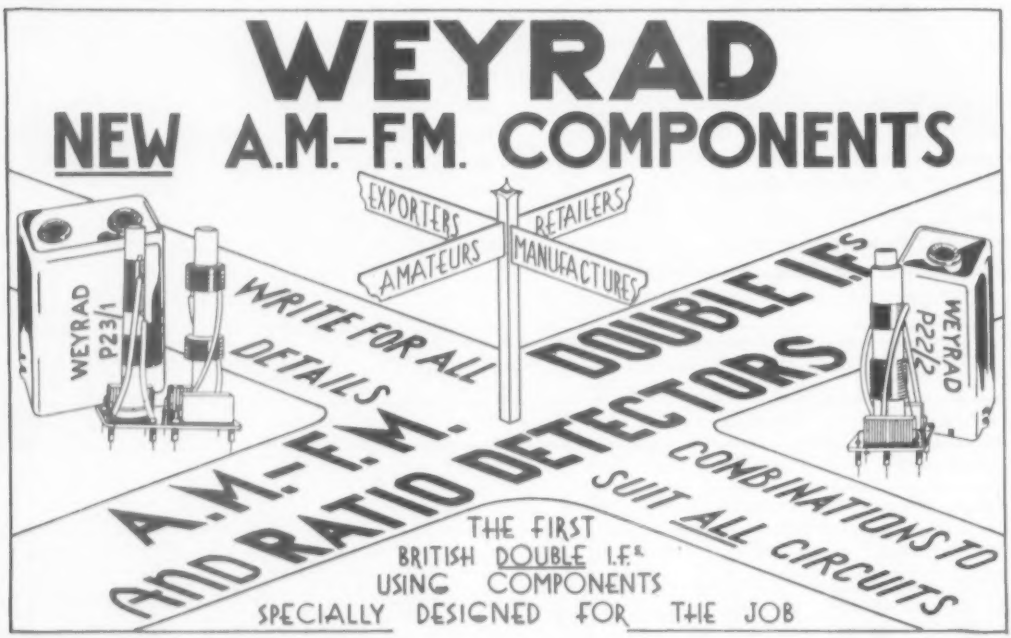

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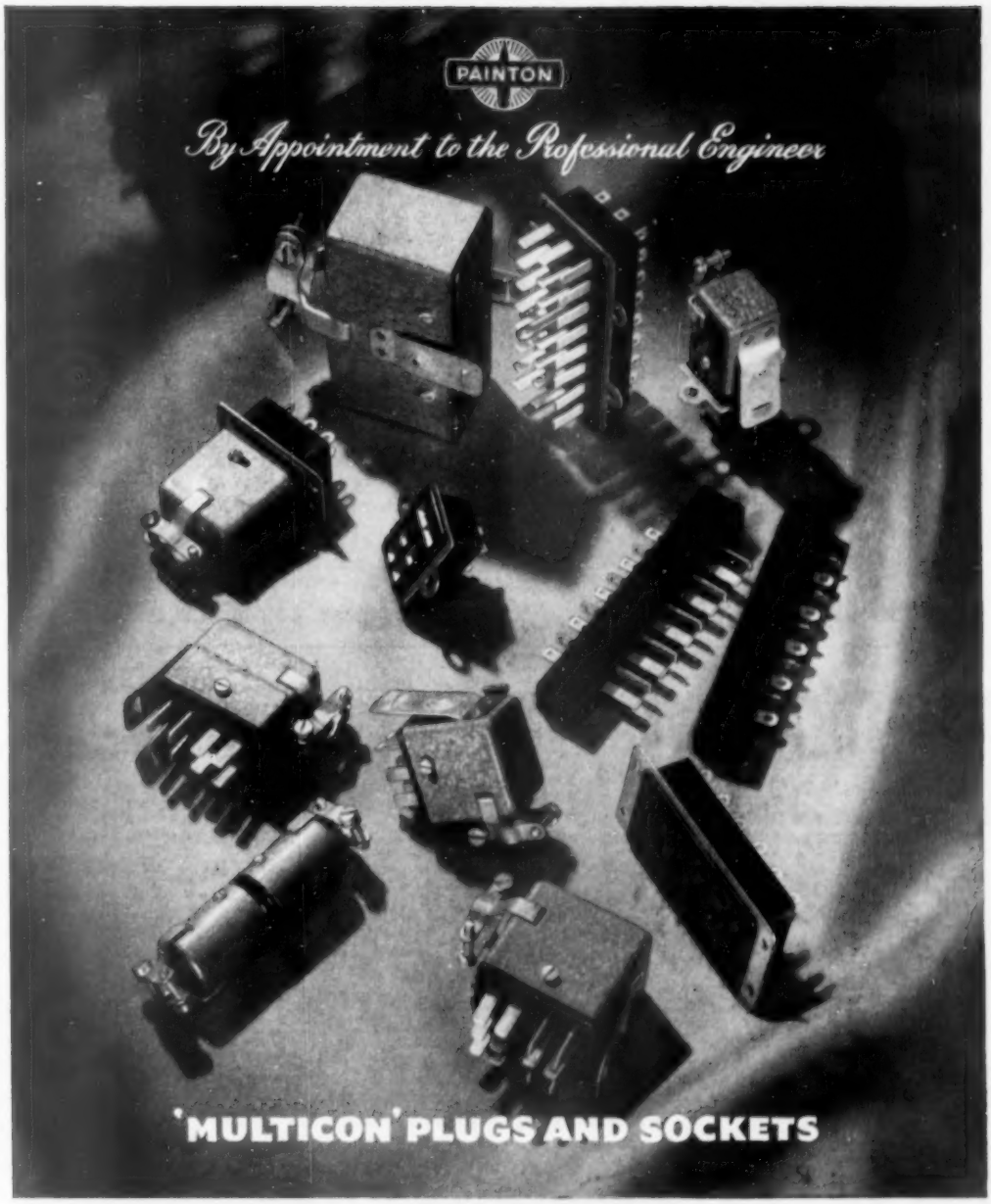

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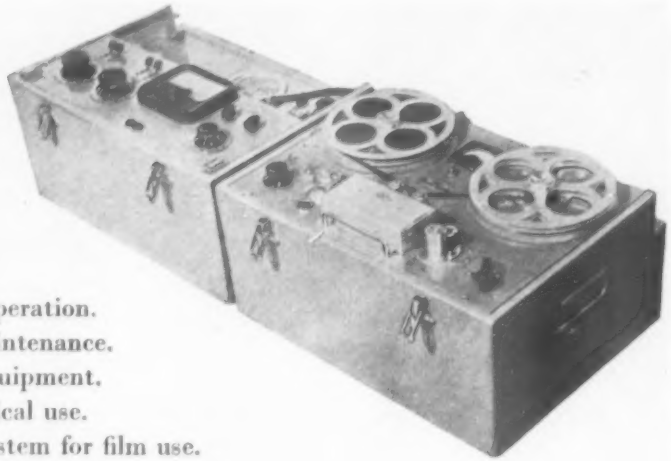

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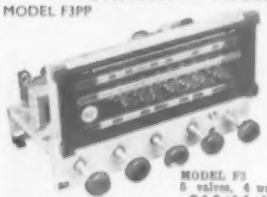

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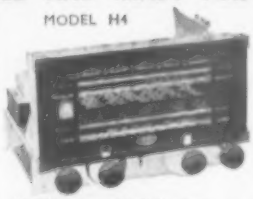

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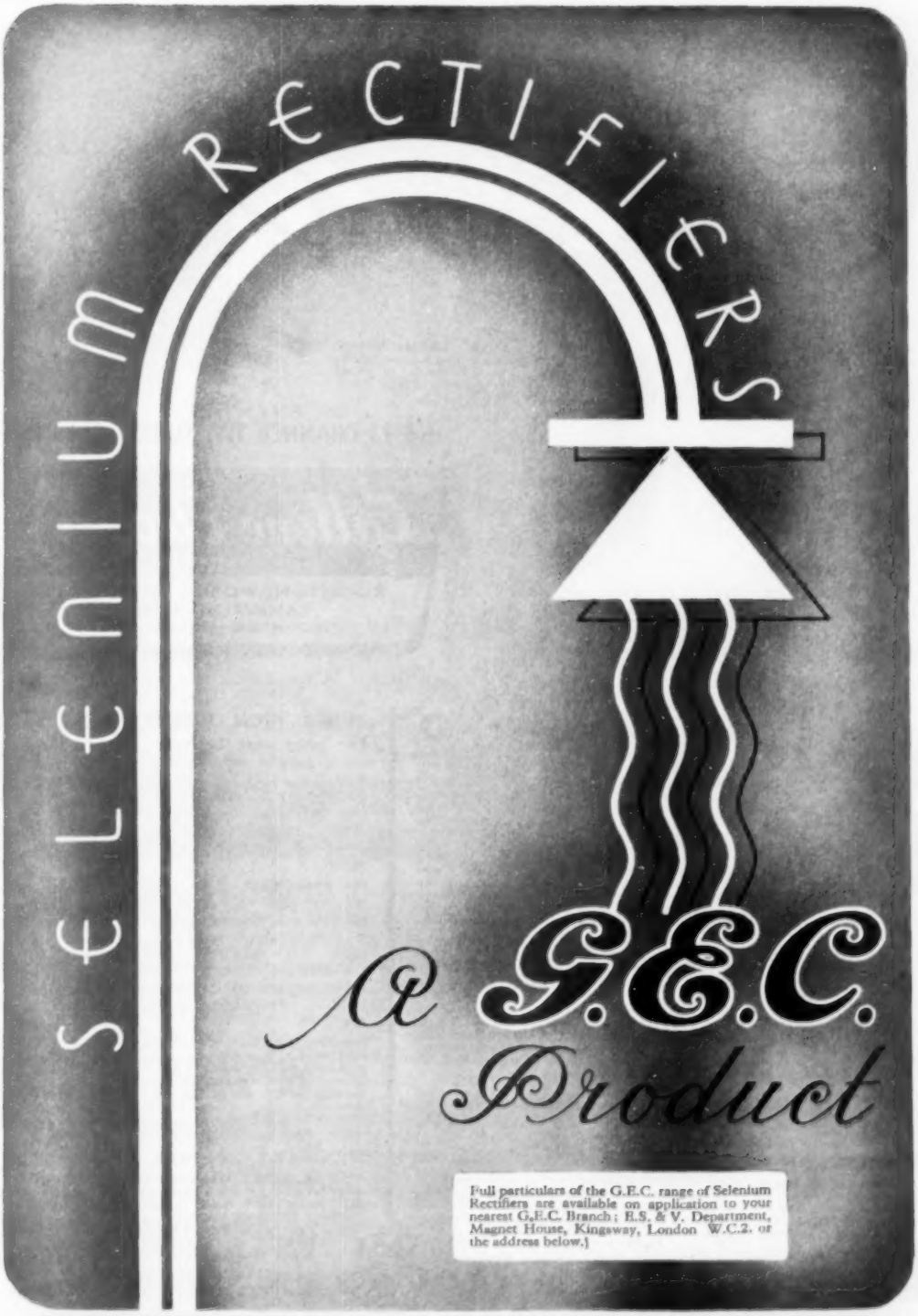
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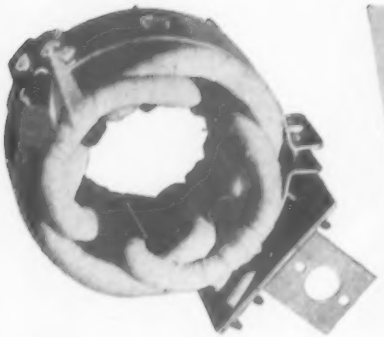

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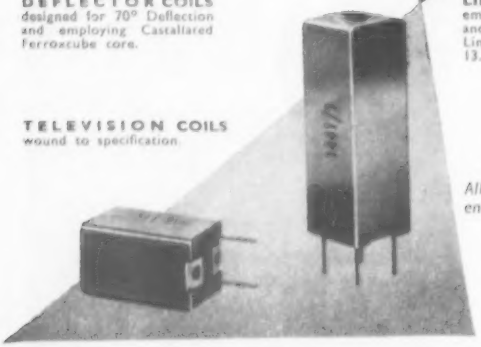

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The TSL LORENZ LPH 65 is the basic treble speaker used in the TSL LORENZ Sound System. Round in shape to ensure smooth melodious sound the plastic cone is fully tropicalised. Special features are the super high flux density magnet of 17,500 gauss and non-perforated back plate.

SOUND SYSTEM

SPECIFICATION LP312-2

IMPEDANCE 15 ohms; **FREQUENCY RANGE** 20-22,500 c/s; **POWER RATING** 25 w.; **PEAK POWER RATING** 40 w.; **DIAMETER** Bass 12½ inches, Treble 2½ inches; **DEPTH** Bass 7½ inches, Treble 2 inches; **BAFFLE OPENING** 10½ inches; **SPEECH COIL DIAMETER** Bass 1.5 inches, Treble ½ inch; **FUNDAMENTAL RESONANCE** Bass 20 c/s., Treble 1,600 c/s; **FLUX DENSITY** Bass 17,500 gauss, Treble 17,500 gauss; **INTERMODULATION PRODUCTS** under 0.5%; **CROSSOVER FREQUENCY** 2,000 c/s; **FINISH:** Grey and blue vitreous anti-corrosion stove enamel.

RETAIL PRICE £14.19.6. (not subject to Purchase Tax).

SUPER HIGH FIDELITY THIS YEAR

Let your ears be your judge . . . crisp, clear, natural reproduction without coloration with TSL LORENZ speaker units. Ten years ahead in engineering and design this speaker unit will enable you to design and build up a sound system in your own home which will truly add the miracle of LIFE to the magic of music . . .

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Full Scale Deflection for ½ Volt input

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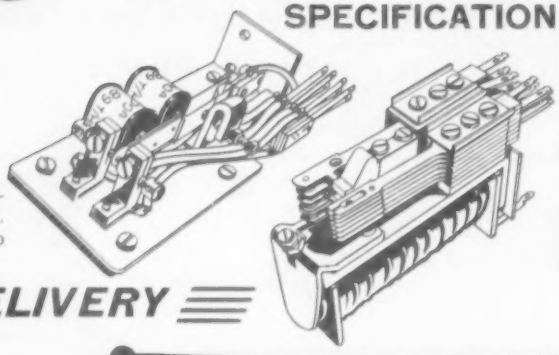

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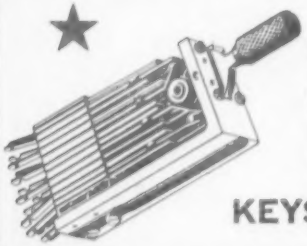

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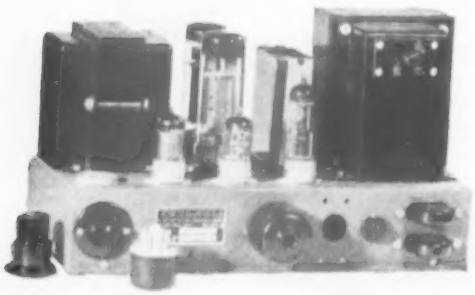

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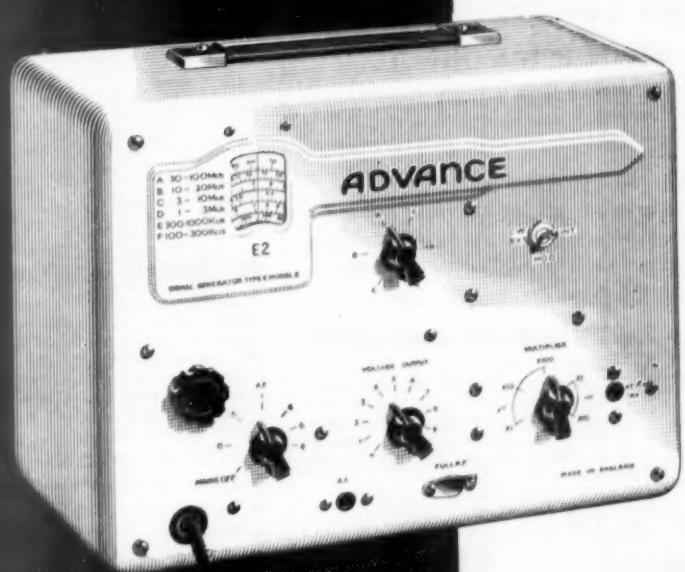

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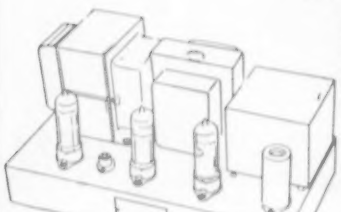

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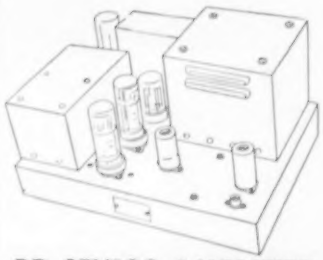

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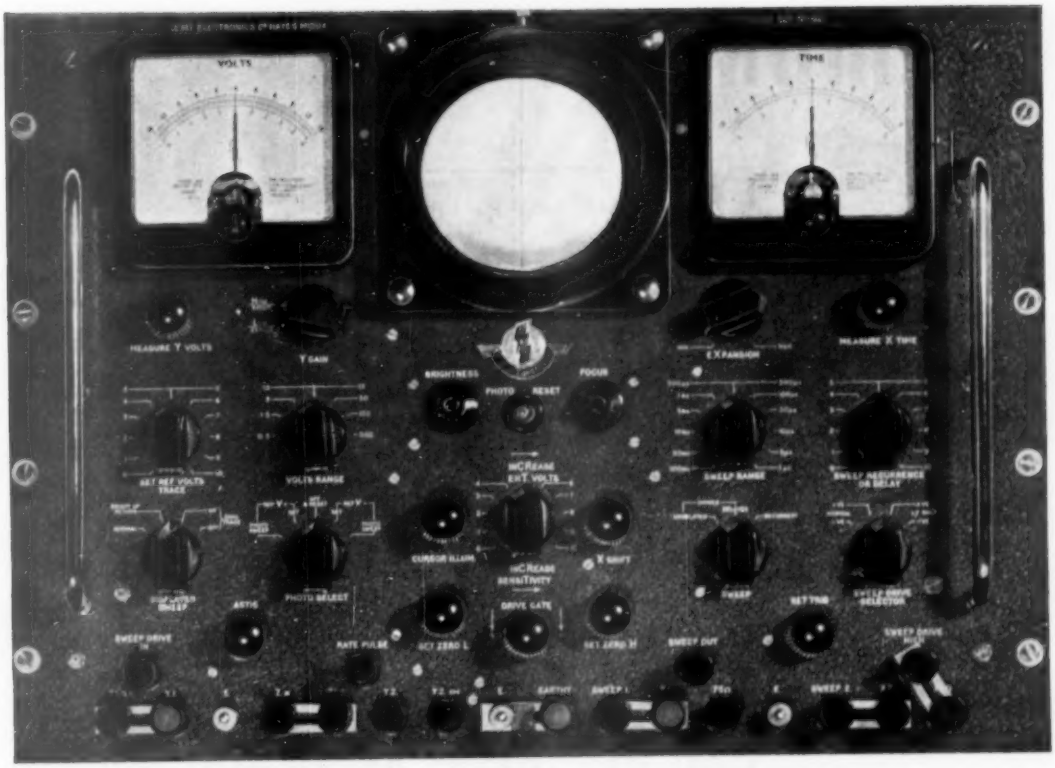

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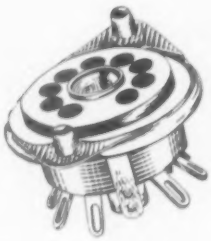

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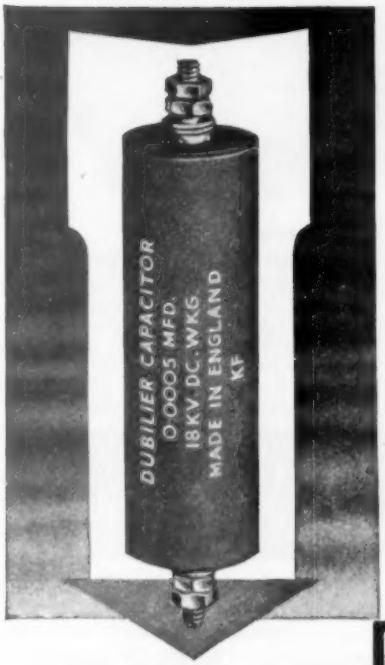

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4.0 kV.	8.0 kV.	0.01 μF.		0.02 μF.		0.03 μF.	
5.0 kV.	10.0 kV.	0.0075 μF.		0.015 μF.		0.02 μF.	
8.0 kV.	16.0 kV.	0.002 μF.		0.005 μF.		0.0075 μF.	
10.0 kV.	20.0 kV.	0.0015 μF.		0.003 μF.		0.005 μF.	
12.0 kV.	24.0 kV.	0.001 μF.		0.002 μF.		0.003 μF.	
15.0 kV.	30.0 kV.	0.0007 μF.		0.0015 μF.		0.002 μF.	
18.0 kV.	36.0 kV.	0.0005 μF.		0.001 μF.		0.0015 μF.	
20.0 kV.	40.0 kV.	0.0003 μF.		0.0007 μF.		0.001 μF.	
25.0 kV.	50.0 kV.	0.0002 μF.		0.0005 μF.		0.00075 μF.	
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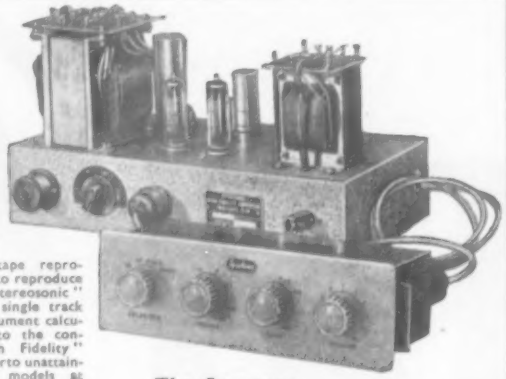

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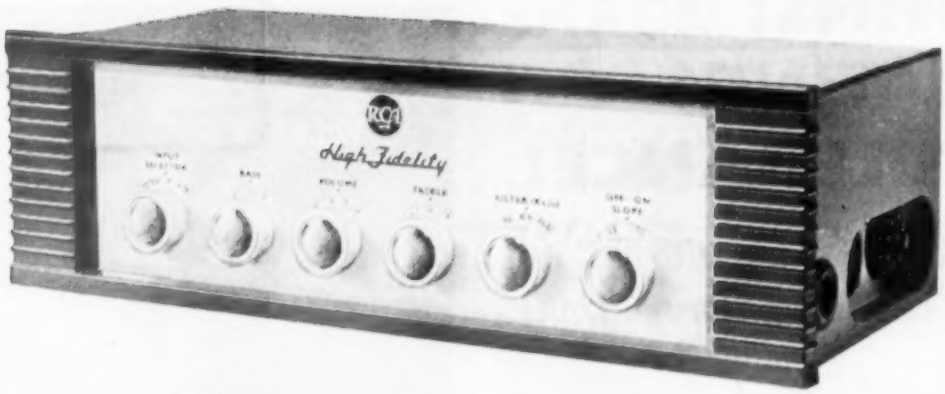

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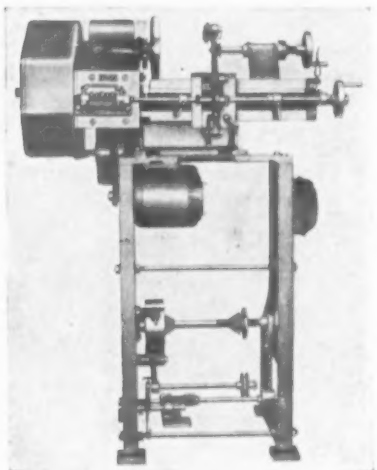

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APS-3	Airborne search	X-band
APS-4	Airborne search	X-band
APS-6	Search/gun aiming	X-band
APS-10	Airborne search/nav	X-band
APS-13	Aircraft warning	420 MC
APS-15	Search/blind bomg	X-band
APT-4	Radar jammer	165-780 MC
APT-5	Radar jammer	
APX1/2	Transponder, IFF	157-212 MC
CPN-3	Ground beacon	S-band
CPN-6	Ground beacon	X-band
CPN-8	Ground beacon	S-band
CPN-17	Ground beacon	S-band
SCR-682A	Harbor search	S-band
SCR-584	Ground radar	S-band
SCR-602	Ground radar	220 MC
SCR-720	Radar aircraft	S-band
TPL	Mobile ground	S-band
TPS-1	Ground portable	1100 MC
UPN-1	Radar, beacon, IFF	S-band
UPN-2	Radar, beacon, IFF	S-band

SD-SF-SG-SK-SL-SN-SO-SQ Navy Radar
VC-VD-VE-VF-VG remote radar repeaters

DYNAMOTORS—GENERATORS—INVERTERS

Type	Used with	Type	Used with
BD-77	BC-191	MG-149H	
BD-86		MG-153F	
BD-94		MP-109	TA-2J-24
DA-19A	RTA-1B	PE-59	SCR-240
DM-21	BC-312	PE-73	BC-375
DM-28	BC-348	PE-75	MANY
DM-32	COMMAND	PE-77	EE-97
DM-33	COMMAND	PE-86	RC-19
DM-34	SCR-506	PE-94	SCR-522
DM-35	SCR-508	PE-95	SCR-499
DM-36	SCR-508	PE-98	SCR-522
DM-37	SCR-508	PE-101	SCR-515
DM-40	SCR-506	PE-103	SCR-284
DM-41	SCR-506	PE-104	SCR-284
DM-42	SCR-506	PE-108	SCR-543
DM-43	SCR-506	PE-109	SCR-269
DM-53	RC-103	PE-125	SCR-245
DM-64	SCR-508	PE-218	SCR-519A
DM-65	SCR-508	PE-237	SCR-694 and GRC-9
DY-1	ARR-2X		
DY-2	ARR-2	PU-7	VARIOUS
DY-9	ARC-1	PU-16	VARIOUS
DY-10	ARC-4	800-1	VARIOUS
DY-11	ART-13	PE-110	SCR-534
DY-12	ART-13	PE-112	SCR-518
DY-17	ART-13	PU-6/TPS-1	TPS-3
DY-21	ARC-3	PP-4	APQ
DY-22	ARC-3	PP-51	APQ
GN-35		PP-87	APT-4
GN-37	SCR-178	PP-104	APT-5
GN-45	SCR-284	RA-34	BC-191
GN-59	PE-162	RA-38	SCR-268
GN-58	SCR-694	RA-42	BC-639
HRU-28		RA-62	SCR-624
MG-149F		RA-87	TELETYPE

TELEPHONE AND TELEGRAPH

BC-1016	CW ink tape recorder
BD-71	6 line switchboard
BD-72	12 line switchboard
EE-8	Field phone
EE-83	Line test set
EE-99	Telephone repeater
RC-261	Remote control
TG-5	Code oscillator
TG-10	Ink tape reproducer
TG-34	Code practice keyer
TP-9	Long range field phone

Civilian and military telephone and telegraph centrals, carriers, switchboards, facsimile and teletype.

TEST EQUIPMENT

TS-3/AP	Power and freq. meter	S-band
TS-7/ASQ	Magnetic compensator	
TS-10/APN	Altimeter test set	Delay line
TS-12/AP	Standing wave ind.	X-band VSWR
TS-13/AP	Sig. gen. freq. mtr.	X-band
TS-14/AP	Sig. gen. pwr. mtr.	S-band
TS-15/AP	Fluxmeter	1.2-4.5K GAUSS
TS-16/APN	Altimeter test set	340-7250 CYC
TS-18/AP	Voltage divider	100 : 1-15 : 1
TS-19/APQ-5	Calibrator	491.04 MC
TS-23/APR	Altimeter test set	
TS-24/ARR-2	Test oscillator	246 MC
TS-27/TSM	Line test set	0-50 MEG, 1-3 MFD
TS-28/UPN	Synchroscope	
TS-32/TRC-1	Test oscillator	1 KC FM, 70-100 MC
TS-33/AP	Frequency mete:	X-band
TS-34/AP	Portable oscilloscope	Fast sweep
TS-35/AP	Sig. gen. pwr. and freq. mtr.	X-band
TS-36/AP	Power meter	X-band
TS-45/APM-3	Power and freq. meter	X-band
TS-46/AP	Frequency meter	S-band
TS-47/APR	Signal generator	40-560 MC
TS-51/APG-4	Goniometer	
TS-55/AP	Standing wave ind.	L-band
TS-59/APN	Delay line altimeter	High alt.
TS-61/AP	Echo box	S-band
TS-62/AP	Echo box	X-band
TS-67/ARN-5	U/with RC103/ARN5	
TS-69/AP	Calibrator freq. meter	4-1KMC
TS-74/UPM	Attenuator and phantom ant.	S-band
TS-75/U	Test meter	U/with TS76
TS-76/APM-3	Wave guide kit	U/with TS45
TS-78/U	Phantom antenna	100-156 MC
TS-89/AP	Voltage divider	X- and S-bands
TS-91/TPS-1	Echo box	1050-1110 MC
TS-92/AP	Broad band alignment	20-250 MC
TS-95/AP	Decade resistor	22.85 : 1
TS-100/AP	Oscilloscope circuits/ sweep	
TS-102/AP	Range calibrator	Blue wave 227.6 KC
TS-108/AP	RF dummy load	X-band
TS-110/AP	Echo box	S-band
TS-111/CP	Wavemeter	S-band
TS-117/GP	Wavemete, absorption	S-band
TS-118/AP	RF wattmeter	20-1000 MC, 5-500 W
TS-120/UP	Sig. gen. pwr. meter	X-band
TS-125/AP	Power meter	S-band
TS-126/AP	Radar range calibrator	400 YD. PIPS
TS-127/U	Frequency meter	375-720 MC
TS-131/AP	Field strength meter	20-3000 MC
TS-133/UPM-1	Wavemeter	115-235 MC
TS-134/UPM-1	Wavemeter	460-570 MC
TS-146/UP	FM Sig. gen. wave and pwr. mtr.	X-band
TS-147/UP	Sig. gen. pwr. freq. meter	X-band
TS-148/UP	Spectrum analyser	X-band
TS-155/UP	Pulse generator	S-band
TS-159/TPX	Sig. gen. pwr. freq. mtr.	150-200 MC
TS-170/ARN-5	Test oscillator	332.6-335 MC
TS-173/UR	Frequency meter	90-450 MC
TS-174/U	Frequency calibrator	20-280 MC
TS-175/U	Frequency calibrator	85-1000 MC
TS-182/UP	Signal generator	167-187 MC
TS-184/AP	Echo box	400-430 MC
TS-192/CPM-4	Wavemeter	S-band
TS-204/AP	Reflectometer	
TS-218/UP	Tuned cavity	X-band
TS-228/AP	Wattmeter to K KW	400-425 MC
TS-247/APM-46	Wavemeter	215-575 MC
TS-250/APR	Altimeter calibrator	Delay line
TS-251/UP	Loran sig. generator	1700-2010 KC
TS-258/UP	Sig. gen. pwr. and freq. mtr	X-band
TS-259/AP	FM signal generator	
TS-263/TPS-10	Sig gen. wattmeter	X-band
TS-268/U	Xtal rect. test set	
TS-270/UP	Echo box	S-band
TS-278/AP	Test set	400-420 MC
TS-297/U	Multimeter	
TS-309/U	Sweep generator	5-65 MC
TS-323/UR	Frequency meter	
TS-352/U	Multimeter	
TS-375/U	Voltmeter	
TS-382/U	Audio oscillator	100 KC
TS-505	Vac. tube voltmeter	
I-45	Megohmeter	0-1000 MEG
I-49	Wheatstone bridge	0-10 MEG
I-56	Tube tester voltohmeter	
I-72	Signal generator	190 KC-32 MC
I-82	Dynamotor test set	
I-88	Generator	470 MC
I-90A	Signal generator	100-156 MC
I-100	Radio ATIF test set	
I-130A	Signal generator	100-156 MC
I-203A	Bolometer	S-band
I-208	Signal generator	1.9-45 MC
I-221A	Signal generator	8-230 MC
IE-17	Handy talky test set	
IE-19	SCR522 test set	100-156 MC
IE-30	SCR522 test set	
IE-46	IFF test set	156-166 MC
IE-66	IFF test set	160-186 MC
BC-221	Frequency meter	125-20?0.0 KC
BC-375	Signal generator	75 MC
BC-1066	Test receiver	150-225 MC
BC-1077	Signal generator	S-band
BC-1268	Modulator unit	
BC-1277A	Sig. gen. pulsed	S-band
BC-1267	Oscilloscope	

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Fifty thousand square feet of testing laboratories, reconditioning shops and warehouses is your assurance of the very finest service and stock. All our equipment and material are pretested and checked out with a full money-back or replacement guarantee. Complete inspection facilities are available on our premises.

GOOD STOCKS — GOOD SERVICE — GOOD VALUE

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RT-34-APS-13. 17 miniature valves. 5-6J6, 9-6AG5, 2-20D1, 1-VR105. Brand new American equipment in original cartons. Complete with manual and dynamotor. £3/19/6. Carriage 5/-.

WAVEMETER Type W1310

Continuous coverage from 155 to 230 Mc/s. Complete with valves, chart and test prod. Input 230 volts 50 cycles. As new. £3/19/6. Illustrated in April issue.

TRANSFORMERS

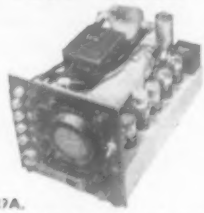
E.M.I. pick-up transformers. To match low impedance high fidelity pick-ups. Potted. 4/6. Post 1/6.

MOVING COIL MICROPHONE

By famous maker. A high-grade microphone combining excellent close speaking performance with low background pick-up. Attractively styled and finished in black and chromium. Brand new, boxed. £3/19/6. See illustration in April issue.

U.S.A. MULTIMETER

Still a few available as advertised in April issue at £5/19/6. Post 2/6.



U.S.A. INDICATOR UNIT Type BC927A.

Complete with CR tube 3 HP1 shield and holder. 7 valves. 2-6H6GT, 1-6X5GT, 1-2X2, 2-6SN7GT, 1-6G6. Brand new in original cartons. £2/19/6. Carriage 5/-.

RT 40/APNIX U.S.A. ALTIMETER

Complete with 14 valves. Loose stored, less dynamotor. 29/6. Carriage 4/6. For details and illustration see April issue.

VCR97

Brand new boxed 12/6.

Post insurance 5/-.

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tape recorders, recording tape. Hi-Fi equipment, etc., etc.
High part exchange allowances on new equipment.

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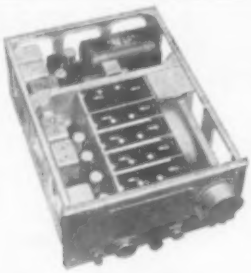

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2 ranges. 0-250 V. and 0.15 V. D.C. Press button. At 12/6 each.

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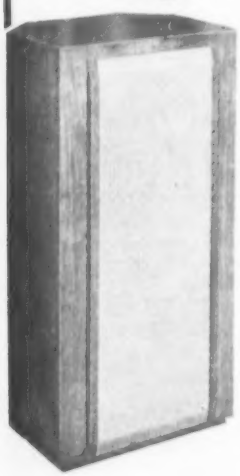

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The **MODEL CR50 BRIDGE** measures from 10pF to 100 mFd and from 1 ohm to 10 megohms in fourteen ranges, having a total scale length of 120 inches. Indication of balance is given by a magic eye fed from a high gain pentode amplifier. Designed for bench use with case and panel of steel, finished black crackle. Complete with valves and instructions ready for use from A.C. mains. ONLY **£7/18/-** plus 4/6 carr./packing.

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VV50 VALVE VOLTMETER measures up to 250 volts A.C., R.F., and D.C. with input impedance of 11 megohms. ONLY **£7/19/6**, plus 4/6 carr./packing.

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104/1 Rogers Minor Mark III	£14 0 0
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"88" & "99" ARE NOW AVAILABLE IN A RANGE OF 4 SPOOL SIZES

suitable for *ALL* Tape Recorders

EMITAPE ACCESSORIES

RANGE OF EMPTY PLASTIC SPOOLS IN CARTONS

For programme storage and other special purposes.
AP.93 3"
'Message' Spool 3/-
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NON-MAGNETIC SCISSORS AP.39

Made from non-ferrous metal these scissors prevent magnetisation when cutting the tape.
AP.39 16/-

P.V.C. EITING AND MARKER TAPES

A range of coloured tapes for colour-coding when editing, indexing, etc.
White AP. 38/1
Red AP. 38/2
Yellow AP. 38/3
Blue AP. 38/4
Orange AP. 38/5
Green AP. 38/6
4/6 per reel.

TAPE JO NTING COMPOUNDS FOR P.V.C. BASE AP.77 FOR C.A. BASE AP.35

Special fluids to provide welded joints for either P.V.C. or Cellulose Acetate base tapes.
4/6 per bottle
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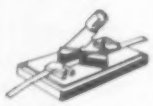
TAPE JOINTING BLOCK AND CUTTER AP 46



Provides for the accurate alignment and splicing of the tape. The non-magnetic cutting blade ensures a soundless joint.
17/6

GUMMED JOINTING TAPE AP.37

Provides a simple method of joining Magnetic Recording Tape when editing, etc.
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ES10

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THE WORLD'S FINEST MAGNETIC RECORDING TAPE

"88" GENERAL PURPOSE

SPECIAL FEATURES

• HIGH SENSITIVITY • ANTI-STATIC • PRE-STRETCHED P.V.C. BASE • FREEDOM FROM CURL • LOW "PRINT THROUGH" FACTOR • METALLIC CONTACT STRIPS FOR "AUTO-STOP" FITTED TO ALL EXCEPT "MESSAGE" SPOOL • P.V.C. LEADER AND TRAILER STRIP

EMITAPE '88' is a standard thickness base tape giving maximum durability for "general purpose" use.

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Both types of Emitape have identical magnetic oxide coatings and electrical characteristics.

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TYPE No.	TITLE	SIZE	LENGTH APPROX.	PRICE
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★ 99/3	"	"	250'	£0 . 9 . 6
88/6	"Junior"	5" dia.	600'	£1 . 1 . 0
★ 99/9	"	"	850'	£1 . 8 . 0
88/9	"Continental"	5½" dia.	850'	£1 . 8 . 0
★ 99/12	"	"	1200'	£1 . 15 . 0
88/12	"Standard"	7" dia.	1200'	£1 . 15 . 0
★ 99/18	"	"	1800'	£2 . 10 . 0

★ *LONG PLAY*

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EMITAPE '77' for special application where extensive accuracy of sensitivity levels is required.

EMITAPE TEST TAPE (CCIR STANDARD)

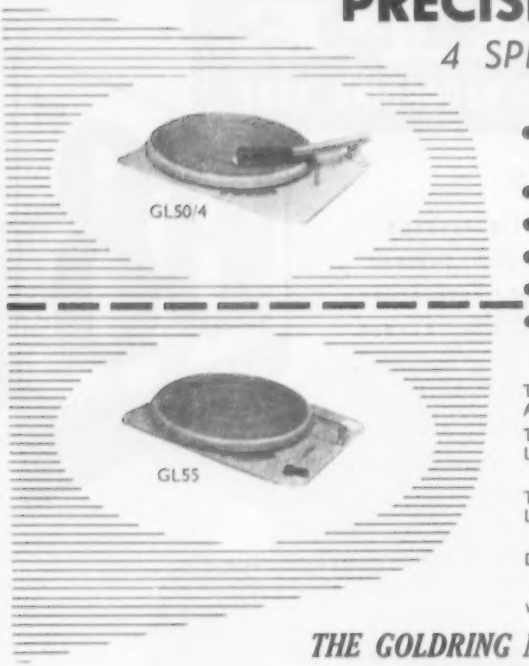
The following range is available to special order.

SRT 11	SRT 12	SRT 13
Speed 30" per sec.	Speed 15" per sec.	Speed 7½" per sec.

PRECISION *High Fidelity*

4 SPEED TRANSCRIPTION UNITS

WITH VARIABLE SPEED ADJUSTMENT.



MAIN FEATURES

- Speed **continuously variable** from 29 r.p.m. to 86 r.p.m. Pre-set adjustable "click-in" position for 78, 45, 33⅓ and 16 r.p.m. Playing old celebrity discs requiring speeds above 78 r.p.m. Tuning record pitch to a musical instrument. Correcting for mains frequency variations.
- Accurately balanced heavy precision made turntable eliminates Wow and Flutter.
- Unique VERTICAL EDGE-DRIVE PULLEY principle eliminates Rumble.
- Less than 1% change in speed for up to 13% change in Line Voltage.
- Large resilient 4-pole constant velocity motor.
- Model G.L.50/4 and G.L.56 fitted with weight adjustable precision Pick-up-Arm with plug-in shell, incorporating the **Superb Goldring Variable Reluctance Cartridge No. 500.**

Goldring LENCO

TYPE GL50/4 Low loading velocity operated Automatic Stop — *Price* **£15.15.0** *P.T.* **£6.2.10**

TYPE GL55. Without Pick-up. FITTED WITH BAND LOCATION DEVICE — *Price* **£12.12.0** *P.T.* **£4.18.4**

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MODEL 18

SOLDERING INSTRUMENT

6-6.3 v. 18 WATTS

7½" LONG. WEIGHT 1 oz.

BIT SIZE 3/16". LIST PR. 35/-

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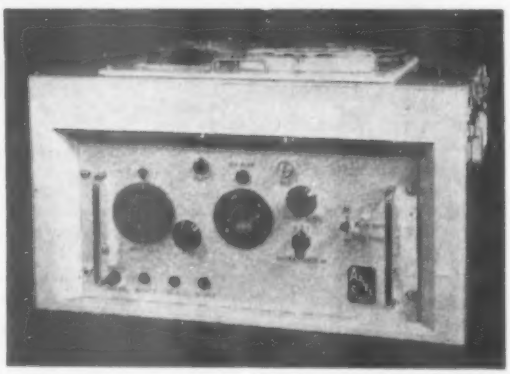

The above shows one of the two units which comprise our new Portable Professional Tape Recording Equipment Type 8/WB/1. The following salient features should be noted:—

- ★ **Tape speeds of 15 and 7½ i.p.s. or 7½ and 3¾ i.p.s.; performance at all these speeds to Master Tape standards.**
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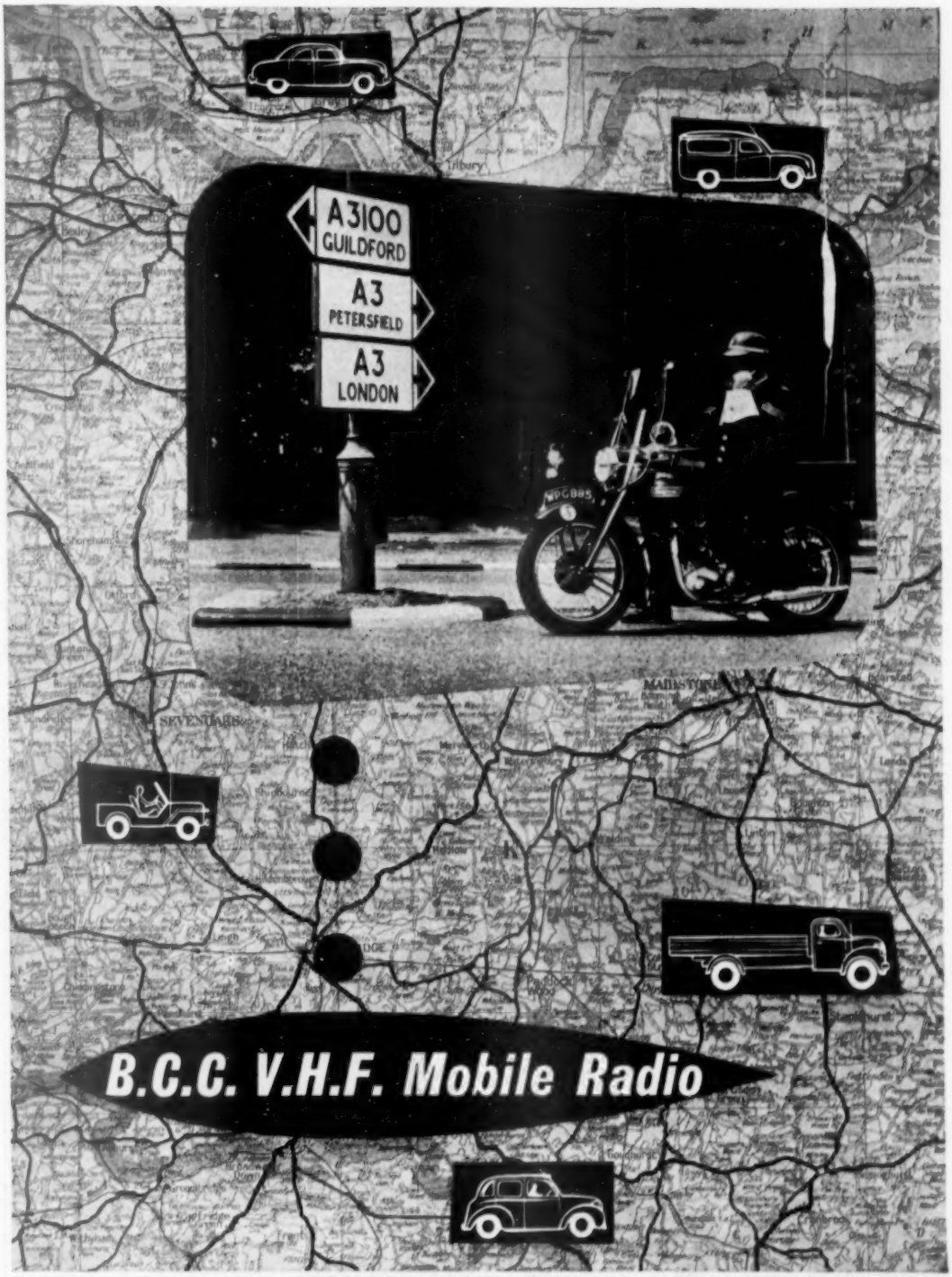

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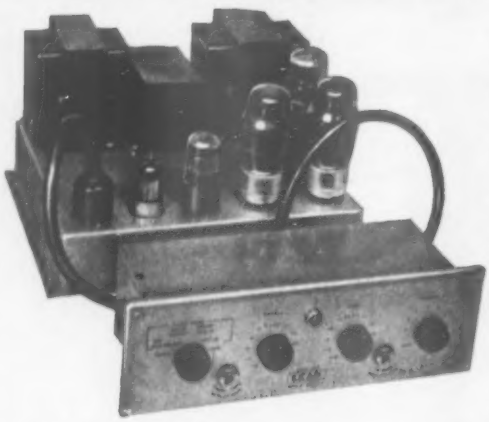

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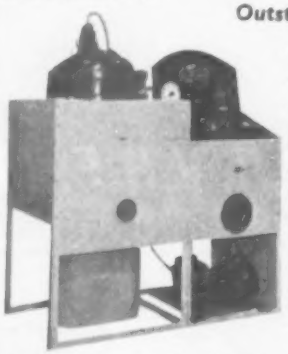

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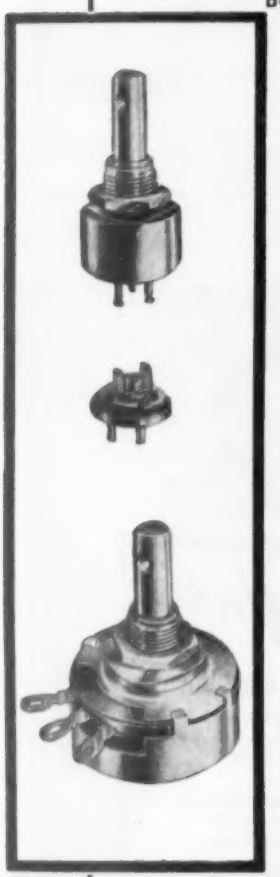

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Rating: ambient 70°C	¼ watt
Temperature Cat.	40/70°C
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Minimum Resistance	50 ohms max.
Overall Diameter	23/32 in.
Overall depth of control from mounting face, including tags	⅝ in.

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Type Approved to Certificate No. 974 Issue 1, Ref. TA1373, this pre-set, open-type control is of particular interest to industrial communication and Service equipment manufacturers.

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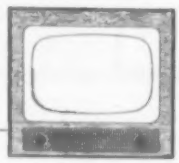
100 ,,	4.3	4.8	3.2	3.6	2.2
200 ,,	6.3	7.2	4.9	5.3	3.3
Dimensions (inches)					
Centre Conductor	1/0.022	7/0.0076	1/0.029	7/0.010	1/0.044
Over Cellular TELCOTHENE	0.093	0.093	0.128	0.128	0.200
Over Wire Braid	0.117	0.117	0.152	0.152	0.230
Over TELCOVIN sheath	0.157	0.157	0.202	0.202	0.290



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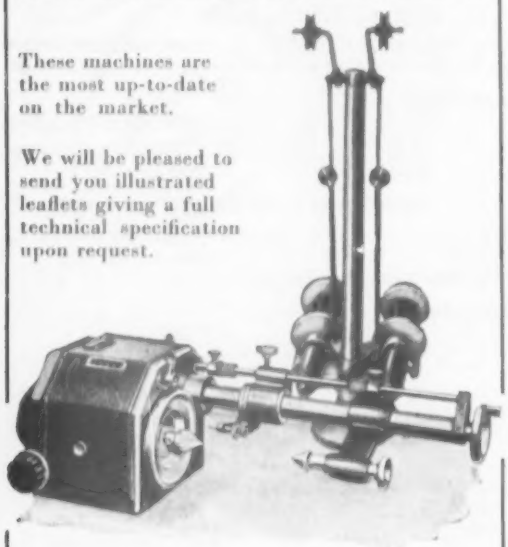

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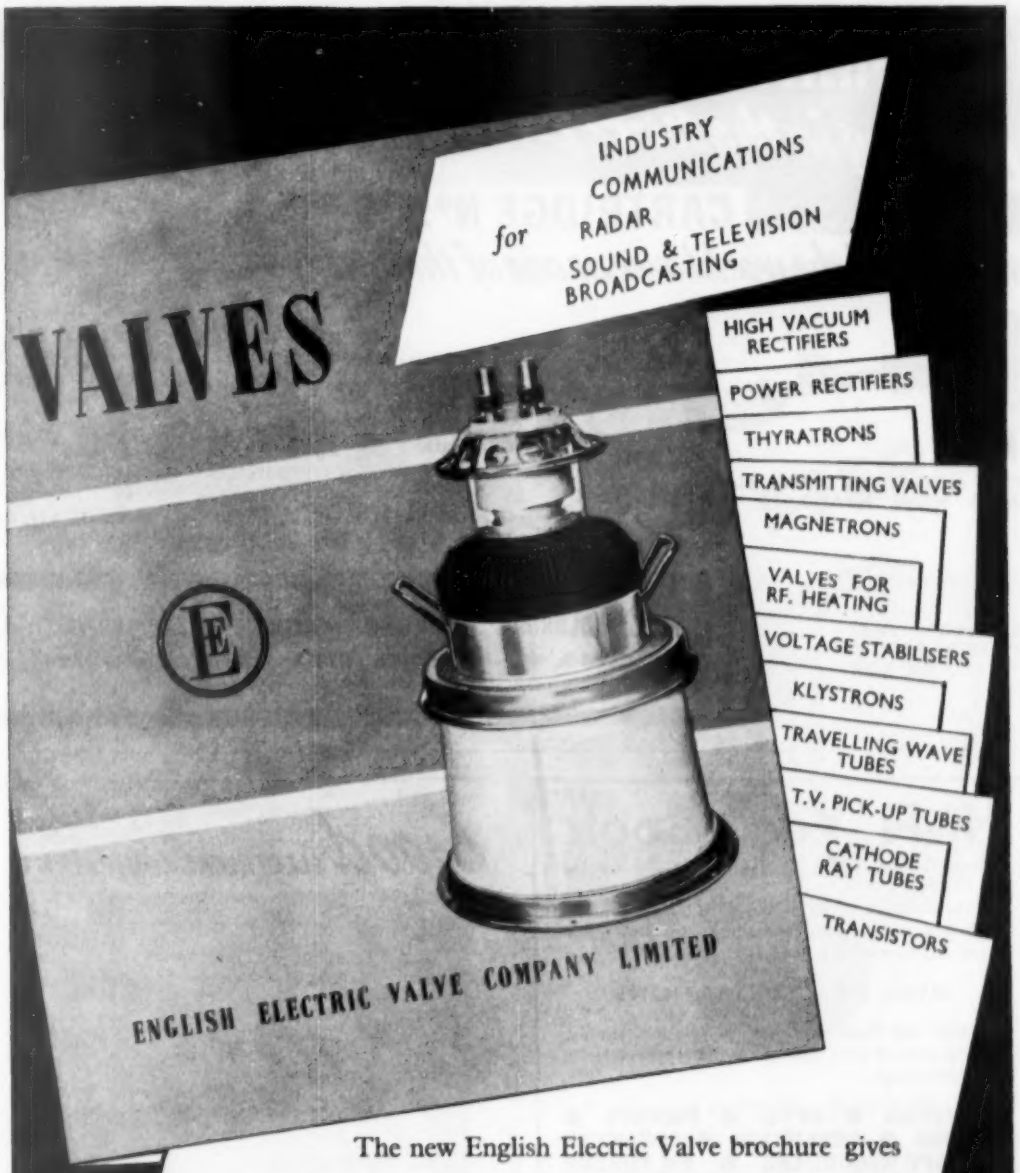

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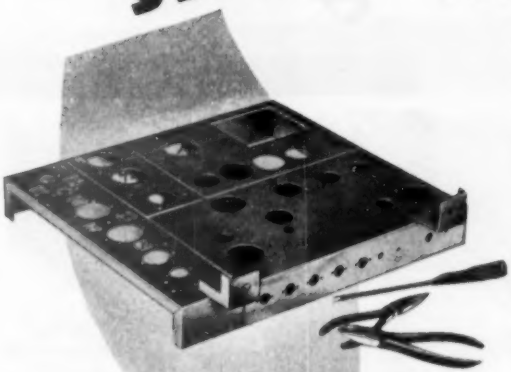

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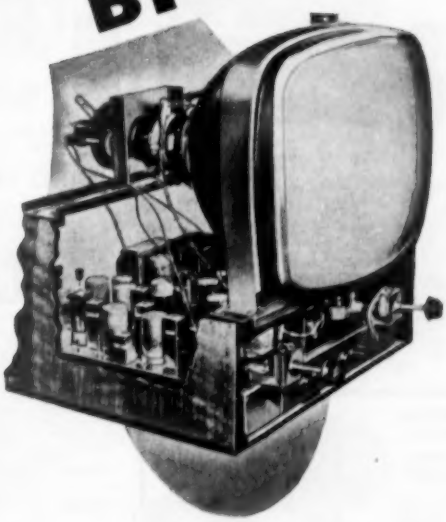

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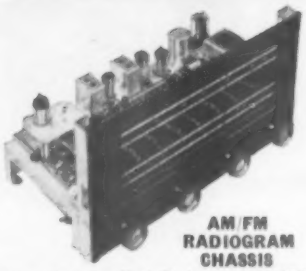

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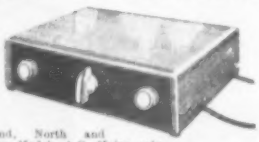

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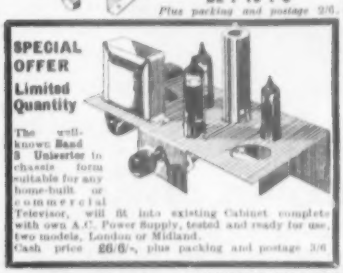

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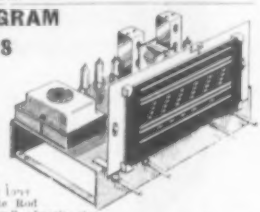

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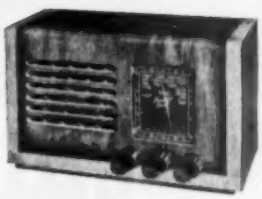

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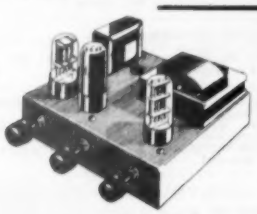

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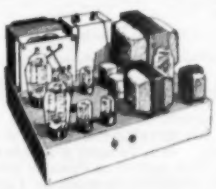

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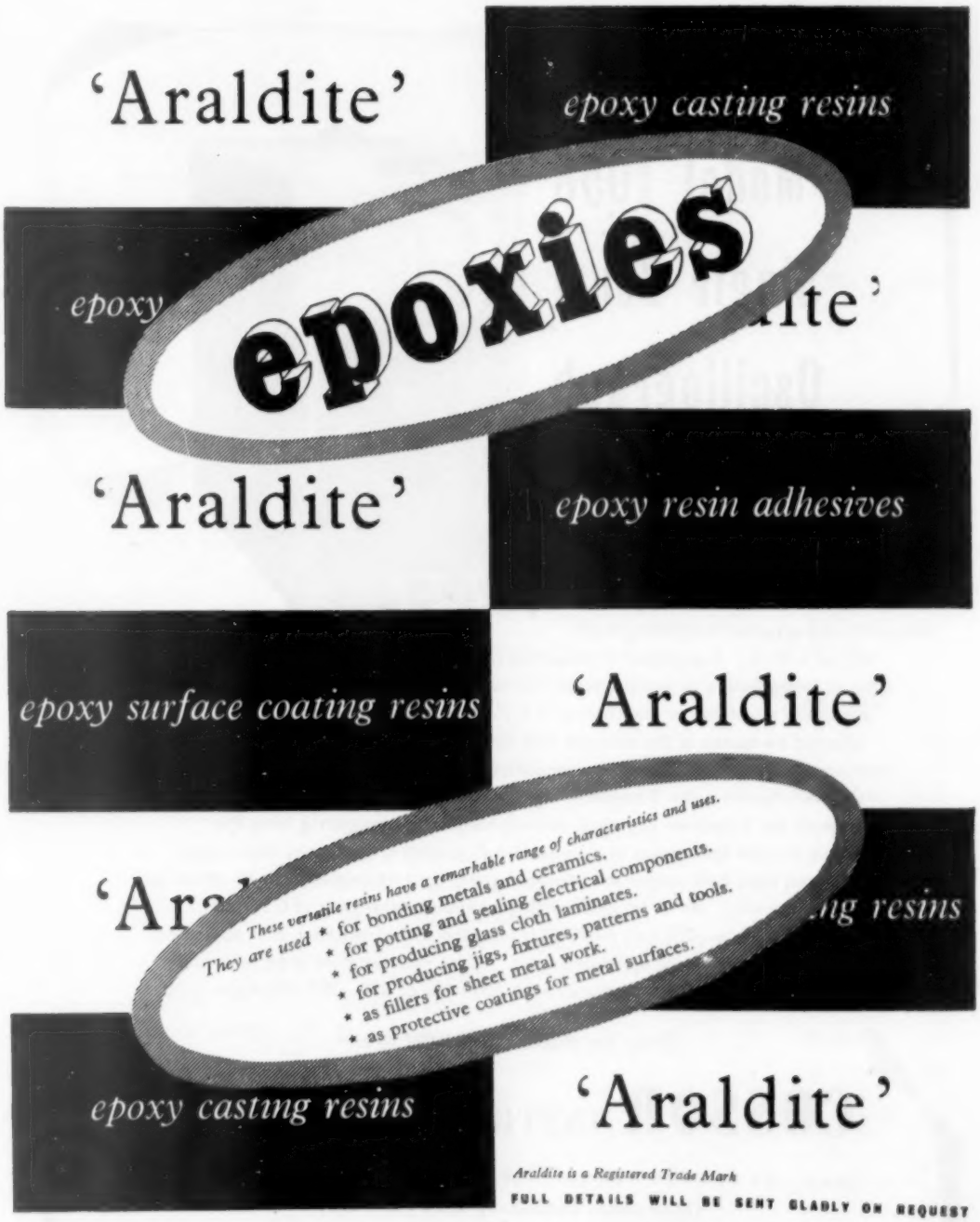
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Wireless World

ELECTRONICS, RADIO, TELEVISION

Managing Editor: HUGH S. POCOCK, M.I.E.E.
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Assistant Editor: F. L. DEVEREUX, B.SC.

MAY 1956

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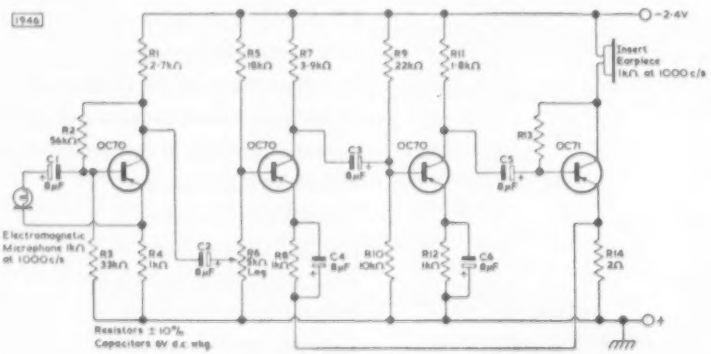
TRANSISTORS IN AUDIO AMPLIFIERS (Part One)

The best known and most practical application of transistors is in low power audio amplifiers. For example, about 90% of the hearing aids made commercially in this country at the present time are transistorised. Although the design of hearing aid circuits is somewhat specialised, the circuit shown here illustrates many of the basic principles of transistor amplifier design.

High gain is obtained by operating the transistors in the grounded emitter connection, that is, with the emitter common to the input and output circuits. The a.c. input is applied between base (b) and emitter (e), and the output current flows between emitter and collector (c). A d.c. base current has to be provided to bias the transistor to the chosen working point. The simplest method is to take the base bias from the h.t. line by a series resistor. If the method is applied to the third OC70 in the circuit, R10 has to be omitted and a new value given to R9. However, some form of d.c. stabilisation is normally included in all audio amplifier stages, since the collector current is dependent on current gain and the very temperature-sensitive collector leakage current $I'_{c(o)}$.

The simplest method of providing some d.c. stabilisation of the working point is shown for the OC71 output stage. The bias resistor R13 is connected to the collector instead of to the h.t. line. When the collector current is higher than its correct value for the d.c. working point, the base current is reduced because of the fall in collector voltage, so that the collector current automatically tends to return to its correct value.



More effective d.c. stabilisation is provided by an emitter resistor and potential divider arrangement such as R9-R10. The current through R9 is greater than that through R10, the difference being the base current which flows from + to − out of the transistor. When the collector current is higher than the required value, the increased voltage drop across the bypassed emitter resistor R12 leaves less voltage available from emitter to base. Hence the base input current is reduced, and the collector current tends to return to its correct value.

The high d.c. stability of the potential divider arrangement is obtained at the expense of slightly higher drain on the battery because of the shunting of R9 + R10. With this arrangement the base current can be reversed into the positive direction, when the corresponding values of collector current are less than $I'_{c(o)}$; if the process is taken far enough, I_c can be made to approach nearly to $I_{c(o)}$. Here $I'_{c(o)}$ is the value of I_c when the base is open circuit ($I_b=0$). It is related to the diode reverse current $I_{c(o)}$ flowing in the grounded base circuit with the emitter open circuit ($I_e=0$) by the current gain of the transistor appropriate to this low level operation.

Other features of the circuit require only brief mention. R8 and R12 are bypassed for d.c. stabilisation, and while R4 is not bypassed, there is no loss of a.c. gain as the input is applied between base and emitter. A value of 8 or 10μF is typical for the coupling capacitors. The first OC70 provides an input impedance of 1kΩ which matches the microphone and is not appreciably shunted by resistors of the values shown for R2 and R3. Negative feedback (12dB) is applied over three stages from R14, and for maximum undistorted output the value of R13 is chosen to match the α' of the OC71 such that $R13 = \alpha' R_L$.

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MVM 351

Wireless World

MAY
1956

Vol. 62 No. 5

Sound in Width and Depth

ALTHOUGH the principle of stereophonic sound reproduction has been a subject for discussion among technicians for a lifetime, and has been demonstrated at intervals since the latter half of the last century, it is only recently that it has become a matter of common experience—as a sideshow at exhibitions, in the cinema and even as a medium for concert hall performance.

The advent of first-class commercial twin-track records enables those who can afford the necessary equipment to enjoy a new listening experience in the home which goes far beyond the "three-dimensional" diffusion of sound from a single-channel source. The use of paralleled multiple loudspeakers with divergent axes in conjunction with acoustic reflectors and diffusers offers scope for endless experiment and is capable of giving "atmosphere" and many pleasing effects which are absent from a small single-cone loudspeaker in a simple mounting. Elementary movement of the apparent source can be effected by the simple expedient of "pot-panning" in which panoramic movement of the sound is caused by increasing the volume of sound in one loudspeaker at the expense of another through the medium of a potential divider which may be manually or electronically controlled. All such methods may be conveniently classed as "pseudo-stereophony" even though the results in many cases are far from deserving the derogation implied by the term.

We would admit as stereophonic any system which makes an analysis of the sound field at the source into two or more channels and uses the information in these channels to reconstitute those elements in the original sound which are essential to realism. A successful stereophonic system provides more than the obvious effects of movement and life and is characterized by a subtle clarity and definition which is sustained at all volume levels within the capacity of the reproducing equipment.

Many diverse systems have been proposed and are being used for domestic stereophonic reproduction. Some are founded on mathematical reasoning, others on empirical experience, the best on both. None is yet comprehensive (which accounts for the absence of the word "height" from the title of this comment), or foolproof. Occasionally some incongruous, not to say bizarre, effects can be produced, such as fluctuations in the apparent size of instruments according to the register in which they happen to be played. There are also wide divergencies between different systems in their tolerance to movement on the part of the listener. The heaviest responsibility rests with the recording engineer and the studio manager in seeing that the information recorded on the tape tracks is unambiguous and reasonably proof against the sort of maladjustments which may be expected to occur from time to time at the reproducing end.

The creation of an illusion of reality in reproduced sound depends ultimately on the validity of the listener's mental imagery and on his subconscious ability to reconcile what he now hears with his stored experience of original sounds. Since exact reproduction of the original sound field is impossible, the most to be expected of a sound reproducing system is that it shall fire the imagination and not introduce any recognizable incongruity.

By this criterion a single-channel system may prove to be the better for some kinds of sound source; the speaking voice, for example, or a solo instrument such as the guitar recorded without reverberation at the source with the object of reproducing it with only the acoustic environment of the listening room. We have heard examples of this technique, of which C. E. Watts is a recognized exponent, that create a perfect illusion that the performance is in the room. Remarkable results are frequently achieved by the B.B.C. through their single-channel sound broadcasting system in giving an illusion of auditory depth by skilful variation and control of the ratio of direct to reverberant sound at the microphones.

Clearly the choice of method must rest primarily with the material to be reproduced. Stereophonic sound is a powerful new addition to the means available for realistic sound reproduction, but in the foreseeable future it will not automatically displace the single-channel system.

WORLD OF WIRELESS

Organizational, Personal and Industrial Notes and News

London I.T.A. Station

BECAUSE of the Government curb on capital expenditure it is now unlikely that the I.T.A. London station will move from Croydon to Crystal Palace next year as planned. The Authority is, therefore, installing a second transmitter at Croydon.

The original transmitter was a prototype lent by Marconi's to expedite the opening of the service. Whether or not that will be retained in service so that the output of the station can be increased to the planned 120 kW e.r.p. or the new transmitter replace the original, is uncertain. The phasing equipment is certainly being installed in readiness for ultimately operating two transmitters in parallel at Croydon.

Radio "Balance Sheet"

DIRECT exports of British radio and electronic equipment during the first quarter of the year were again a record. As will be seen from the figures extracted from the Government's "Trade and Navigation Accounts" the exports from each section of the industry—with the exception of valves—increased by comparison with the first quarter of last year. The overall increase was 17.5 per cent.

It will also be seen that the imports during the same period increased, although not so steeply.

	Exports (£M)		Imports (£M)	
	1956	1955	1956	1955
Transmitters and navigational aids	3.66	2.92	0.61	0.41
Valves and c.r. tubes	0.71	0.73	0.85	0.73
Receivers	1.05	0.97	1.54	1.29
Sound reproducing gear ...	1.73	1.30		
Components and test gear ...	1.98	1.72		
	9.13	7.64	3.00	2.43

"Stereosonic" Concert

A PUBLIC recital of music from H.M.V. "Stereosonic" tape records given in the Royal Festival Hall on 26th April was well attended and enthusiastically received. The programme included orchestral, operatic, organ, piano, violin and solo vocal items which in tonal quality and "presence" were a very close approximation to the real thing. The illusion was strengthened by clever stage lighting in which the orchestral desks and some solo instruments were pin-pointed in the darkened hall.

Normal "Stereosonic" reproducing equipment was used up to the main amplifiers, the power of which was increased to 120 watts for this occasion. The loudspeakers comprised banks of elliptical moving coils for the bass, ribbon units for the upper middle register and electrostatic units for the extreme top. These were assembled in large baffles, one on each side of the stage with their axes directed to give optimum results in the middle stalls. The effects were fundamentally the same as those to be expected from domestic "Stereosonic" equipment.

Jamming: A Two-edged Weapon

IN a concerted effort to stop the use of jamming, the International Short Wave Club has launched a campaign in which it calls on all short-wave listeners to stop sending reception reports to countries operating these "disturbers of the peace." The countries concerned are listed in the following extract from a Foreign Office letter quoted by the I.S.W.C.: "Stations engaged in the systematic and indiscriminate jamming of foreign broadcasts are situated in the Soviet Union, East Germany, Poland, Czechoslovakia, Hungary, Rumania and Bulgaria. It has been established that over a thousand jamming stations operate from these territories." The I.S.W.C. statement goes on to express the hope that the British jamming of Greek broadcasts will cease.

Wireless World commented editorially on international jamming in March, 1940, shortly after the outbreak of World War II. The views then expressed may be thought to have some relevance even to-day:—

> Why . . . do we not institute a campaign of intensive jamming against all German communications? . . . Great Britain and her ally France, having access to jamming sites throughout the world, are very favourably situated geographically for hampering the enemy's wireless communications.
>
> The answer to this question is not far to seek. In the first place, jamming of non-military communications is a typical example of the kind of international lawlessness we are fighting against, and one can rest assured it would only be resorted to by way of reprisal and in the face of the most severe provocation. Large-scale jamming, it must be remembered, would interfere not only with Germany but also with the rights of neutral nations.

Receiver Sales

DESPITE the increased television coverage in Bands I and III provided during the last few months by both B.B.C. and I.T.A., sales of television receivers in the first quarter of the year were some 18.5% below the figure for the same period last year. It will be seen from the table, issued by the British Radio Equipment Manufacturers' Association, that the percentage decrease in the sales of sound receivers and radiograms was even higher—31.5% and 51% respectively.

The hire purchase or credit sales in March (as a percentage of the total sale) were: sound 31%, radiograms 54% and television 46%. The comparable figures for March, 1955, were 41%, 62% and 59% respectively.

	Sound		Radiograms		Television	
	1956	1955	1956	1955	1956	1955
Jan.	66,000	98,000	18,000	35,000	85,000	103,000
Feb.	66,000	99,000	15,000	33,000	81,000	98,000
Mar.	67,000	95,000	12,000	24,000	67,000	85,000
Totals	199,000	292,000	45,000	92,000	233,000	286,000
	−31.5%		−51%		−18.5%	

PERSONALITIES

Sir Edward Appleton, K.C.B., D.Sc., F.R.S., has accepted an invitation to give this year's Reith lectures on "Science and the Nation" which will be broadcast by the B.B.C. in the autumn. Sir Edward, who is in his early sixties, has been principal and vice-chancellor of the University of Edinburgh since 1949. For the previous ten years he was secretary of the Department of Scientific and Industrial Research. In 1924 he was appointed Wheatstone Professor of Physics at King's College, London, where he remained for twelve years. It was during this period that his researches led to the discovery of what is now known as the Appleton layer.

Sir Ben Lockspeiser, K.C.B., F.R.S., has retired from the post of secretary of the D.S.I.R. on reaching the age of 65. Before his appointment in 1949 he had been chief scientist in the Ministry of Supply for three years. He will be succeeded at D.S.I.R. by **Professor H. W. Melville,** F.R.S., who has been Mason Professor of Chemistry in the University of Birmingham since 1948.

Dr. W. Shockley is to take charge of the Shockley Semiconductor Laboratory set up at Stanford, California, by Beckman Instruments Inc., which he joined a few months ago. Dr Shockley, "father of the transistor," was for nearly 20 years with Bell Telephone Laboratories where he was latterly director of transistor physics research.

H. Anglès d'Auriac has resigned from the directorship of the Technical Centre of the European Broadcasting Union in Brussels. In 1946 he was seconded from the French broadcasting service to become director of the Technical Centre which was then operated by the International Broadcasting Organization. M. d'Auriac, who is 46, is succeeded as director by **Georges Hansen** who for nine years has been chief engineer and deputy director general of the Belgian broadcasting organization—Institut National Belge de Radiodiffusion. M. Hansen, who from 1940 to 1945 served with the Belgian Forces in this country, is vice-chairman of the C.C.I.R. Study Group XI (Television) which has recently concluded an international survey of colour television.

R. A. Cail has left E.M.I. Engineering Development Ltd., where, since 1953, he had been senior engineer, to become chief engineer of Bonochord Limited who are entering the field of automation. Whilst at E.M.I. he was responsible for the design of the first British numerically controlled production milling machine. Except for his war service at the Royal Aircraft Establishment, Mr. Cail was from 1935 to 1953 with McMichael Radio where, for seven years, he was assistant chief engineer. **Dr. F. Roberts,** M.Sc., who was with the Bendix Aviation Corporation in the United States, has also joined Bonochord as senior development engineer.

J. Thomson, M.A., D.Sc., is the new director of the British Scientific Instrument Research Association in succession to **A. J. Philpot,** C.B.E., M.A., B.Sc., who is retiring after 36 years with the Association. Dr. Thomson, who is 51, joined the Admiralty Signal School, Portsmouth, in 1939 and after spending the war years in research on micro-wave devices and the years immediately after the war in developing tactical radio communication equipment for the Navy, he was appointed professor of physics and electrical engineering at the Royal Naval College, Greenwich. Since 1951 he has been deputy director of physical research at the Admiralty with responsibility for research and development of valves on behalf of the three Services. Dr. Thomson is author of the recently published third volume of "The Services' Textbook of Radio," entitled "Electronics," which covers valves, c.r. tubes and transistors.

A. B. Pippard, M.A., Ph.D., elected a F.R.S. "for his work on the electrical properties of metals at radio-frequencies, and for his studies of the super conducting state," has been lecturer in physics at Cambridge since 1950 but is at present visiting professor at the Institute for Study of Metals, University of Chicago. During the war (1941 to 1945) Dr. Pippard, who is 35, was in the Scientific Civil Service engaged on the design of microwave transmission systems and radar aerials.

R. G. Colby, chief of the radio and television test section of A. C. Cossor Limited, at Highbury, since 1951, has been appointed manager of the company's service department at 51 Calthorpe Street, London, W.C.1. (Tel.: Terminus 0077.) He has been with Cossor since 1937, having previously been on the staff of E.M.I. During the war he was chief inspector at two of the Cossor shadow factories.

W. R. Daniels, who was until recently with the Pye organization where he was working on photo-conduction camera tubes, has joined 20th Century Electronics Limited as production engineer. For some years he worked with Professor Lallemand in Paris and has considerable experience in the photo-electric field particularly in relation to pick-up tubes, multipliers and radiation detection devices.

Sydney H. Brewell, M.B.E., the new chairman of the Radio and Electronic Component Manufacturers' Federation, is chairman and managing director of A. H. Hunt (Capacitors), Ltd. He is also vice-president of Hunt Capacitors (Canada), Ltd., formed two years ago. Before joining Hunts in 1932, Mr. Brewell was for three years with the Gramophone Company.

J. W. Soulsby, the new chairman of the Radio Officers' Union, has been a seagoing radio officer with the Marconi Company since 1918 and a member of the Union's executive committee since 1944. He is 56.

The new vice-chairman of the Radio Officers' Union is **G. W. Cussans,** who started his radio career as an

Sir Edward APPLETON.

R. A. CAIL.

S. H. BREWELL.

W. R. DANIELS.

operator with the Marconi company but subsequently joined what is now B.O.A.C. From 1945 to 1948 he was senior radio instructor at Hythe, Southampton.

C. H. T. Johnson, this year's chairman of the Radio Communication and Electronic Engineering Association, is commercial director of Decca Radar, Limited. He joined the Decca organization in 1946 after war service with the R.A.F. Technical Branch. He was initially concerned with the commercial development of the Decca Navigator System, but since 1950 has been with Decca Radar. He is here shown presenting the R.I.C. technical writing premiums.

OUR AUTHORS

Professor Werner Nestel, chief engineer of Nordwestdeutscher Rundfunk since 1947, describes in this issue the development of television in Germany. Since joining N.W.D.R., the broadcasting organization in what was the British zone of occupation, Dr. Nestel has been largely responsible for the reconstruction of the German broadcasting system, including the introduction of frequency modulation.

M. B. Martin, who, with **D. L. A. Smith,** contributes the article in this issue on reproduction from single-channel and "Stereosonic" tapes, has been deputy section leader of the magnetic recording section of E.M.I. Sales and Service since 1953. He joined the company in 1950 and has been continuously engaged on the design of magnetic recording and reproducing equipment. For two years prior to joining the company he was studying at E.M.I. Institutes. D. L. A. Smith, his co-author, who is project engineer for magnetic recording equipment at E.M.I., was for five years with Addison Electric Company where he was engaged on a.f. development work.

V. N. Gray, author of the article on the frequency stabilization of oscillators, has been with A. H. Hunt (Capacitors), Limited, where he is in charge of the test engineering department, since 1953. His radio career began at Murphy's in 1942. From 1946 to 1948 he was in Royal Signals where he was for most of the time radio instructor in the 1st Training Regiment. He afterwards undertook part-time study and obtained his London (External) B.Sc.

IN BRIEF

At the end of March the total number of **broadcast receiving licences** current in the United Kingdom was 14,261,551, including 5,739,593 for television and 293,459 for car radio. The month's increase in television licences was 90,327.

A Broadsheet is to be issued five times a year by the City and Guilds of London Institute giving information on its activities. In the first issue reference is made to the new four-year course for electrical technicians in which specialization in industrial electronics or electrical power equipment is provided for in the third and fourth years.

B.S.R.A. Show.—As already announced the eighth exhibition organized by the British Sound Recording Association opens at the Waldorf Hotel, Aldwych, London, W.C.2, at 10.0 on Saturday, May 26th. It will remain open until 6.45 and be open again from 10.0 to 6.0 the next day. Admission is by catalogue, price 2s. A list of the thirty-seven exhibitors, twenty-six of whom have booked individual demonstration rooms in the hotel, was given last month.

Television Society Premiums.—Only three of the six premiums normally awarded annually by the Television Society were this year presented at the annual general meeting on May 11th. The Pye premium was given to R. A. Rowden (B.B.C.) for his paper "Television Coverage of Great Britain," the E.M.I. premium to W. S. Percival (E.M.I.) for "Distributed Amplifiers," and the Mullard premium to L. C. Jesty (Marconi) for "Progress in Colour Television." Each premium is valued at £5.

The new president of the **British Wireless Dinner Club** is Vice-Admiral J. P. L. Reid, C.B., C.V.O., and the new vice-president is Air Vice-Marshal E. B. Addison, C.B., C.B.E. Particulars of the club, which was originally formed for past and present members of the radio branches of the three Services but now has a wider membership, are obtainable from Captain F. J. Wylie (director of the Marine Radio Advisory Service, Cory Buildings, 117 Fenchurch Street, London, E.C.3) or L. Hinton (Standard Telephones and Cables), who are joint secretaries.

I.E.E. Radio Section.—The membership of the radio and telecommunication section of the Institution of Electrical Engineers now exceeds 5,000—the largest of the four specialized sections of the Institution. The figure at the end of March was 5,232.

Society of Instrument Technology now has an office at 20 Queen Anne Street, London, W.1 (Tel.: Langham 4251) and Commander A. A. W. Pollard, R.N.(Ret.), has been appointed full-time secretary.

FROM ABROAD

E.B.U.—Changes of personnel and administrative offices are announced by the European Broadcasting Union. H. A. d'Auriac has resigned from the directorship of the Brussels Technical Centre and is succeeded by G. Hansen (see "Personalities"). The chief engineer of the Centre—J. Treeby Dickinson—will also be leaving when his extended term of secondment from the B.B.C. ends this year. The Geneva headquarters of the Union are now at Centre International, Rue de Varembé.

French television on 441-lines has been discontinued as a result of a fire at the Paris transmitter. It was originally planned to scrap the system in 1958 but it is now suggested that the station will not reopen. According to a report in our Paris contemporary, *Television*, owners of 441-line receivers are being given a generous allowance on their old sets when purchasing 819-line receivers.

4,500 kW at 537 Mc/s is the effective radiated power claimed by R.C.A. to have been radiated experimentally by a television station in Lancaster, Pennsylvania. The output of the 100-kW transmitter was fed to an aerial having a gain of nearly 50. The maximum e.r.p. for u.h.f. television stations permitted by the Federal Communications Commission is at present 1,000 kW.

Soviet Receiver Production.—The sixth five-year plan of the U.S.S.R. (1956 to 1960) provides for a 255 per cent increase in the production of sound and television receivers compared with 1955. The output of receivers in 1960 is planned to reach 10.2 millions.

A monument is to be erected in Yugoslavia to mark the centenary in July of the birth of **Nikola Tesla,** whose name will go down to posterity because of his early experiments in the transmission of electrical energy by wireless.

BUSINESS NOTES

Decca Radar announce that in the six years since they entered the marine radar field with their "Woolworth set"—Type 159—their equipment has been ordered for over 5,000 ships of all classes operated by over 1,000 shipowners throughout the world. This figure is stated to be over 30 per cent of the world's radar-equipped vessels. The navies of twenty-seven countries have also fitted Decca radar. Since the smaller version—Type 212—for coasters, etc., was introduced in March last year, over 1,000 have been sold.

The I.T.A.'s second northern television station—on Emley Moor, near Huddersfield—is to be constructed entirely by **Marconi's**. The equipment will be similar to that installed on Winter Hill, Lancs, comprising a 7.5 to 10 kW vision transmitter and 2.5 kW sound transmitter. The aerial, which will be directional, will give a vision e.r.p. of 200 kW.

Sea Wave Communications Limited has been formed with offices and showrooms at 13, South Molton Street, London, W.1, for the manufacture of small transmitters and marine radio-navigational aids. The first two products are a marine portable direction finder and a 25-watt marine radio-telephone. The organization has also been granted the sole distributing rights for the United Kingdom of Hallicrafters communication equipment. The managing director of the company is H. R. Adams (G2NO) who was with the McElroy-Adams Group, until recently Hallicrafters agents in this country. J. G. Maitland-Edwards (G2GS) is also a director.

A division for the design and production of industrial electronic control units has been formed by **Bonochord Limited,** of 48, Welbeck Street, London, W.1. The division will also provide an automation advisory service.

The production of **Belling-Lee** television aerials and accessories has been started in Melbourne by their subsidiary company, Belling & Lee (Australia) Pty., Ltd. Among the members of the firm going to Australia in an advisory capacity is I. A. Davidson, senior research engineer.

The new 5-valve superhet, the Enfo, fitted in the Ford company's Zodiac, Zephyr Six and Consul cars, has been developed and is being manufactured by **E. K. Cole Limited.**

Tape Recorders (Electronics) Limited, makers of the "Editor" and "Playtime" recorders, have moved from Fitzroy Street, London, W.1, to 784-788, High Road, Tottenham, with factories at 14 and 17 Wingate Estate, London, N.17. (Tel.: Tottenham 0811.)

Simon Sound Service have opened a service department, adjoining their main offices, at 46 George Street, Portman Square, London, W.1. The manager is H. Dowsett who has been with the firm nine years.

I.T.U. STAMP.—The work of the International Telecommunication Union is symbolized in this stamp being used by the United Nations postal administration in New York. Across the centre of the design is a morse tape symbolizing telegraphy, the dial in the centre, telephony, and the intersecting circles the radio aspect of the Union's work.

Staar Electronics, Ltd., has been formed by Gas Purification and Chemical Co. Ltd. (of which Grundig and Wolsey Television are subsidiaries) to manufacture and sell in Great Britain and export to the U.S.A. the automatic record-playing equipment developed by Usines Gustave Staar, of Brussels. The managing director of the new company is R. B. Page, who was with Birmingham Sound Reproducers and previously with Plessey. A. E. Johnson, who is an executive of both Grundig and Wolsey, is also a director.

From May 31st, **G.E.C.** broadcast and television receivers will be available from approved radio dealers only.

A serious fire at the Feltham, Middlesex, works of **Valradio Limited** has necessitated the acquisition of new premises. The opportunity has been taken to bring together the departments previously located at Wraysbury, Feltham and Kentish Town, in the new factory and offices at Browells Lane, Feltham, Middlesex. (Tel.: Feltham 4242.)

OVERSEAS TRADE

The list of goods which the **Soviet Union** is desirous of purchasing from the United Kingdom during 1957/60 includes equipment for the manufacture of valves and transistors (75 to 100M roubles), sound and television equipment, measuring and control devices, communication equipment and instruments for the automatic control of technological processes (80 to 100M roubles) and equipment for "manufacturing radio apparatus using printed circuits" (50 to 75M roubles). In a statement from the Board of Trade the first two classes are listed under the heading "Some types are subject to embargo" and the latter class under "Goods about which further information is needed."

The **U.S.S.R.** has ordered two 3-camera television outside broadcast vehicles and ancillary equipment, including centimetric vision and sound links, from Marconi's.

East Germany.—An order for £30,000 worth of television studio equipment for East Germany has been received by Pye Limited as a result of their participation in the Leipzig Fair last February.

Birmingham Sound Reproducers exhibited in the radio and television hall at the German Industries Fair in **Hanover** (April 29th-May 8th).

Iraq's first television station, which was supplied by Pye, started regular broadcasts on May 2nd. The transmitter, which was originally set up at the Baghdad Fair in October, 1954, was subsequently purchased by the Iraq government and has been re-erected on a permanent site.

A radio link providing two reversible television channels between two towns in **Ontario** has been supplied by the G.E.C. The 120-mile link between London and Windsor includes four repeater stations.

Pakistan.—Pye announce the completion of the installation of a radio-telephone service covering the whole length of the gas pipeline between Sui and Karachi, a distance of 350 miles. Eight intermediate relay stations provide a multi-channel radio-telephone and teleprinter service between the two terminals and at five points along the route a mobile radio-telephone service—tied into the main system—is provided for communication with service vehicles, etc. Ericsson Telephones provided the carrier-telephone equipment.

Saudi Arabia.—Dhowaihy and H. Skait, of al-Khobar, have informed the British Embassy at Jedda that they are interested in obtaining United Kingdom agencies for domestic mains receivers, tape recorders and cheap loudspeakers in cabinets. Exporters and manufacturers should write direct to the company and are advised to notify the Commercial Secretariat, British Embassy, Jedda, that they have done so.

Two-Channel Stereophonic Sound Systems

By F. H. BRITTAIN* AND D. M. LEAKEY*, B.Sc.

Basic Requirements for Realistic Sound Location

THE aim of a perfect stereophonic sound-reproducing system is to create for the listeners a similar sound picture in correct aural perspective to that which they would have if transported to an ideal position from which to hear the original sounds. Although this might be possible using a multi-channel system, two channels can, at the best, only recreate the original sounds in correct aural perspective over a limited distance bounded by the two loudspeakers. This is, however, a big improvement over the reproduction available from a single channel system and results in a considerable increase in realism and clarity of the reproduction sound.

The article considers first the particular information used by the brain for the location of sounds, and from a study of this information a two-channel system is devised. In particular a simple method is given for correcting for various listening positions, and it is also shown that the reproduced sound image is more accurately positioned if arrival time differences are overruled and the sound is positioned by intensity differences only.

Information Available for Sound Location.—This subject is dealt with fully in the literature (see, for example, refs. 1, 2, 3). Summarizing the findings of the numerous measurements made it can be said that the brain appears to make use of the following factors:—

(i) Relative loudness of the sound at the two ears.
(ii) Differences in the sound spectrum in the two ears.
(iii) Relative time of arrival and relative phase of sound at the two ears.
(iv) The "quality" of the source as compared with previous knowledge of the quality of a similar source.
(v) The differences both in quality and time of arrival of the direct sound with any reflected sound.

For left-right perception factors (i), (ii), and (iii) appear to be the most important whilst front-back perception and distance perception rely mainly on factors (iv) and (v).

The brain can make use of all the information supplied to it by the ears and the best sound location occurs when all the information is in the same sense. As an example of information in a contradictory sense, in a very live room the reverberation may be louder than the direct sound and arrive from a different position, but by taking into account the late time of arrival of the reverberation the brain is able to ignore the reverberation and to ascertain the true position of the source of sound. This position will not be quite as well defined as it would have been with no reverberation, but it will still be fairly accurate.

Before describing any stereophonic systems, one point of possible confusion should be settled. Throughout these descriptions the term "time difference" between two sounds will be used, and no use of the term "phase difference" will be made. This is because the first is meaningful to random and transient sounds and ambiguous for repetitive waves, whilst the second is relatively meaningless for random and transient sounds but applicable to repetitive waves. Since directional location and stereophonic effects are very much better for random and transient sounds the time difference concept will be used.

Experimental Two-channel system.—Fig. (1) shows the layout of an experimental two-channel system set-up to investigate various effects. It is necessary to give the system an exact size because whilst intensity differences are relative, time delay is a scalar magnitude and will not alter in the same way as intensity differences if the experimental system is made larger or smaller. It was decided at the outset that an attempt would be made to obtain stereophonic reproduction over a front of ten feet and that the listener should be situated somewhere on a line ten feet long and eight feet or more away from the base line of the two loudspeakers.

The first experiment was to ascertain the extent to which two loudspeakers, placed ten feet apart, could simulate a single source of sound when heard by a listener in position L3, that is, equidistant from both loudspeakers and facing the centre of the loudspeaker base line. It was found that with the sound levels from the two loudspeakers equal the listener perceived an apparent single sound source straight in front of him. Extreme movement of the head by the listener tended to produce a splitting of the sound image into two separate sources, but fortunately this effect is not serious unless the listener is consciously trying to listen to each of the loudspeakers independently.

Now if the observer moves from listening position L3 to position L2, then the virtual sound image moves towards one side, in this case towards LSA. This is as would be expected since LSA is now nearer the listener than LSB, and hence the intensity of the sound from LSA is greater and has an arrival time in advance of that from LSB. This is the most serious and the most often encountered fault in two-channel stereophonic systems. It means that the system works correctly only for listening positions on the centre line between the two loudspeakers. However, within limits this fault can be compensated for by the use of directional loudspeakers.

Considering listening position L1 with both loud-

* Research Laboratories of The General Electric Co., Ltd. Wembley.

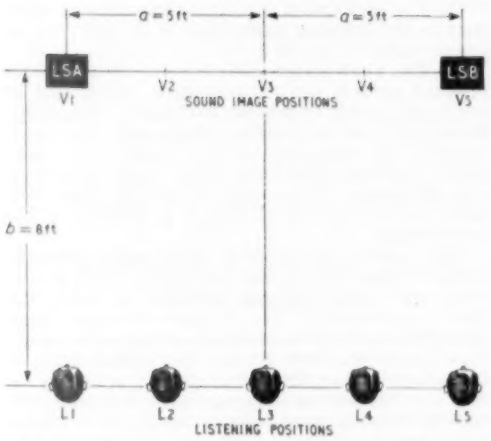


Fig. 1. Layout of experimental stereophonic system in an echo-free room. In this test the loudspeakers LSA and LSB are non-directional in the horizontal plane.

speakers radiating the same random sound at the same level then

$$\text{Distance LSA to L1} = b$$
$$\text{Distance LSB to L1} = \sqrt{b^2 + 4a^2}$$

∴ At listening position L1 the sound intensity due to LSA will be greater than that due to LSB by the ratio

$$20 \log_{10} \sqrt{\frac{b^2 + 4a^2}{b}} \text{ dB}$$
$$= 10 \log_{10} \left(1 + \frac{4a^2}{b^2}\right) \text{ dB}$$

Also the sound from LSA will be in time advance compared with the sound from LSB by an amount proportional to $\sqrt{b^2 + 4a^2} - b$

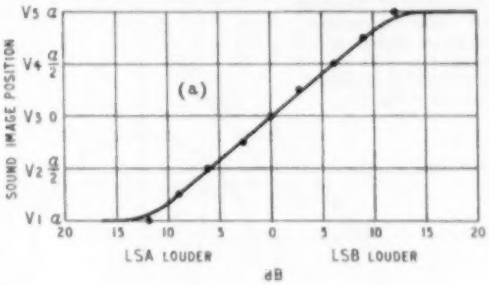
If the distances are measured in feet, the numerical value gives the approximate time advance in milliseconds.

Correction for Position of Observer.—It has been found that it is possible to correct for both these time and intensity differences and to restore the virtual sound image to the mid position by increasing the sound from LSB and decreasing it from LSA. This implies that time of arrival differences can be compensated by sound intensity differences. Such correction has been found possible for time differences up to a maximum of about five milliseconds, after which the position of the virtual sound image becomes less well defined and compensation for time differences greater than ten milliseconds becomes impossible since the sound then splits up into two distinct sources.

By the above method it is therefore possible to obtain good stereophonic reproduction for a line parallel to the speaker base line as well as for the central listening positions. However, using this method of compensation it is found that the stereophonic reproduction is also greatly improved for the area behind the corrected line and hence it is possible to cover an area with satisfactory stereophonic sound.

Experimental Results.—The test procedure was as follows: the listener was first seated in position L3 and asked to name the position from which the sound appeared to come for different relative sound levels from the two loudspeakers. The sound consisted of a short portion of speech of a few seconds duration only. Fig. 2(a) shows the results of these experiments, each point being the average for a number of listeners, each listener making several determinations for a variety of conditions of differences between the loudspeaker sound levels.

The test was then repeated with the listeners in turn in position L1, the results being shown in Fig. 2(b). Note that in this case of "offset" listening the sound intensity at loudspeaker LSB was always greater than that at LSA but that the overall shape of the curve is the same as that for the central listening position but displaced. As a result of these and other tests for the other listening positions it



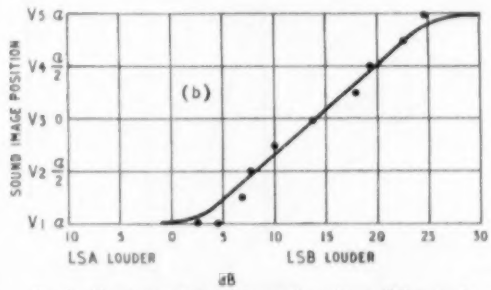


Fig. 2. Movement of sound image by volume difference in the two loudspeakers, (a) for central listening position L3 and (b) for position L1.

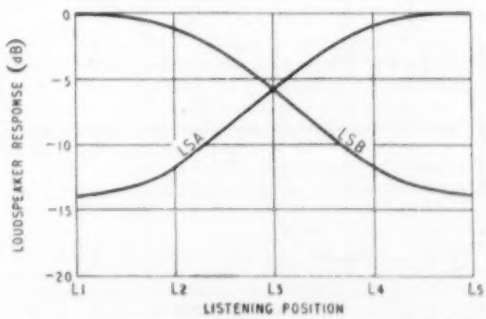


Fig. 3. Loudspeaker responses necessary to correct for off-centre listening positions (Listening line 8ft distant from loudspeakers spaced 10ft apart, as in Fig. 1).

was shown that good definition was possible along the complete listening line.

Directional Loudspeakers.—The above experimental results enable the required ratio of the sound intensities from the loudspeakers towards each listening position to be determined, so as to correct for off-centre listening. As has been indicated, this changing ratio as the listener moves from L1 to L5 can be produced by the use of directional loudspeakers. Considering only the central position for the virtual sound image, which is justified since the sound image position intensity ratio curves were all similar in shape, the requirements to be met can be summarized as:—

(1) The sound image must remain at V3 for listening positions L1 to L5.

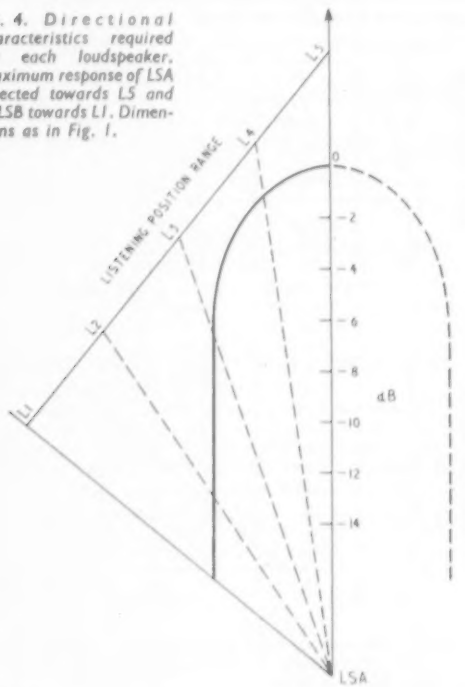


Fig. 4. Directional characteristics required for each loudspeaker. Maximum response of LSA directed towards L5 and of LSB towards L1. Dimensions as in Fig. 1.

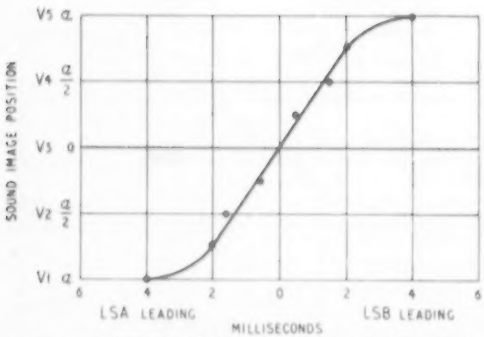


Fig. 5. Movement of the sound image at the central listening position L3 by the introduction of a time difference between the outputs from the two loudspeakers.

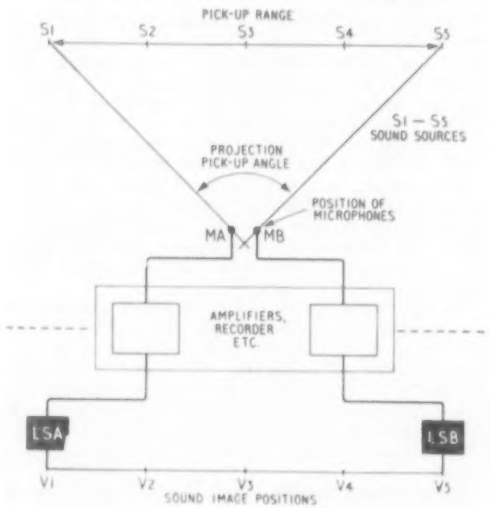
(2) The loudness of the virtual sound image must vary as the observer moves, just as if there was an actual source of sound at V3.

(3) The loudspeaker radiation outside the range directed towards the audience must be reduced as much as possible to prevent undesirable reflections. Reflections are undesirable, since with two loudspeakers the reflections are very liable to be completely different from those which would arise from a single source. This could provide the brain with sufficient information to suggest a splitting of the sound image.

Fig. 3 shows the variation in the sound intensity required from each of the two loudspeakers in the directions of the listening positions to satisfy the above requirements. Fig. 4 shows the same thing plotted as a polar response for one loudspeaker only. This polar response should be independent of frequency; a directional loudspeaker operating at very low frequencies is, however, excessively large, and some compromise must be made. It has been found that for off-centre listening the stereophonic effect does not deteriorate badly if the directionality of the loudspeakers ceases below about 300 c/s and a lower limit of even 1 kc/s provides very acceptable results.

Movement of the Virtual Sound Image.—If the sound is of the character of random noise the virtual sound image can be moved about by two methods. First, as already shown in Fig. 2(a) for an observer at the listening position L3, if the sound intensity levels of the two loudspeakers are different, then the sound image moves towards the louder source. Secondly, if the signal is retarded in time to one loudspeaker, the sound image moves towards the other loudspeaker as illustrated in Fig. 5. In addition a method employing a combination of intensity and time difference could be used and is in fact frequently encountered. It has been found, however, that a sound image moved by an intensity difference between the sound outputs from the loudspeakers remains far sharper and better defined than one where time delay is employed. From Fig. 5 it will

Fig. 6. Complete two-channel stereophonic system.



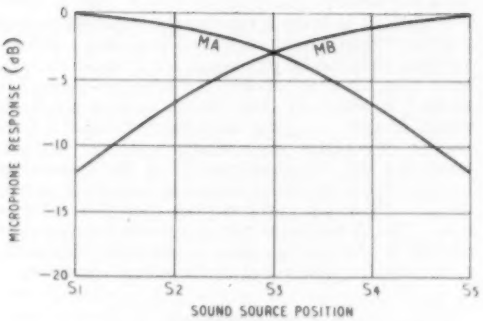


Fig. 7. Microphone responses in direction of indicated sound source for correct positioning of sound images.

be seen that for the experimental system a time delay of about four milliseconds was necessary to move the sound image over to one loudspeaker. Now consider the case if the sound had been repetitive, say with a frequency of 500 c/s. With the loudspeakers radiating the same signal both in intensity and time, the virtual sound image would have been half-way between the loudspeakers. On applying a time delay to one loudspeaker the image would have moved towards the other loudspeaker; however, had the delay been increased to two milliseconds (i.e., one period of the waveform) conditions would have returned to the state of no delay and the sound image would have returned to the central position. Now if the sound had been random or transient in nature it would have remained displaced. Hence for a sound like a piano note which has both a transient part and a fairly steady repetitive component considerable ambiguity would exist as to the exact location of the sound. In practice this effect manifests itself as an apparent widening of the sound image and also as an apparent movement of musical instruments as different notes are played. Hence moving the position of the virtual sound image by varying the intensity levels of the sounds from the loudspeakers is to be preferred.

Sound Pick-up—Microphone Polar Response.—Since it has been shown that the inputs to the two loudspeakers should have a difference of level only and not of arrival time, it follows that the two pick-up microphones should be placed close together to avoid time differences. This in turn calls for some form of directional characteristic or "shadowing" in order that the microphones may differentiate between sound arriving from the left or the right. Before investigating the methods by which these directional characteristics can be produced, it is necessary to ascertain the exact directional characteristics required. Referring to Fig. 6, it is necessary to line up the virtual sound images positions V1 to V5 at the listening end with the actual sound source positions S1 to S5 at the pick-up end of the system. The ratio between the sound intensities from the loudspeakers to position correctly the virtual sound images can be found from Fig. 2(a) and hence the necessary ratio of the responses of the microphones towards each actual sound source can be calculated. At the same time the total output from the loudspeakers must be such that as the virtual sound image is moved from V1 to V5 the loudness changes as if an actual source was moved.

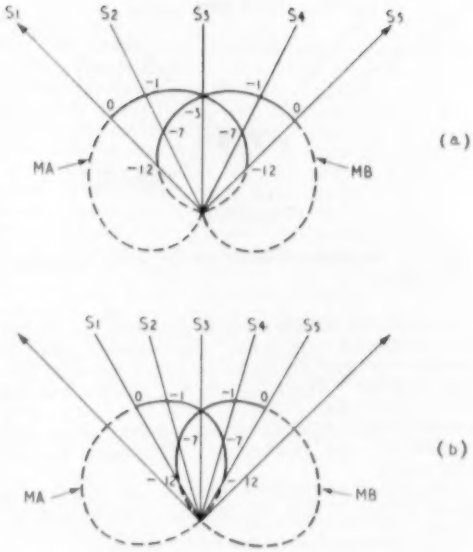


Fig. 8. Polar response curves for microphones for projected pick-up angle (a) of 90° and (b) of 60°.

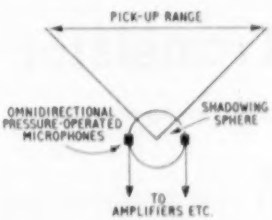


Fig. 9. Stereophonic sound pick-up using artificial head.

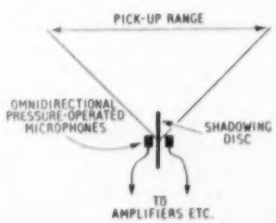


Fig. 10. Stereophonic sound pick-up using shadowing disc.

Fig. 7 shows the necessary microphone responses which satisfy these requirements. Working from Fig. 7 the necessary polar response diagrams can be drawn. Two particular examples are shown in Fig. 8, the first being for a pickup angle of 90° and the second for a pickup angle of 60°.

One of the methods of obtaining the necessary response[4, 5] is to mount two omni-directional microphones in place of the ears in an artificial head as shown in Fig. 9. Such a system depends mainly on intensity difference operated at high frequencies only. Time differences play little part since the maximum time difference which can be obtained from a head of average size is only about 0.6 milliseconds and, as can be seen from Fig. 5, this amount produces little movement.

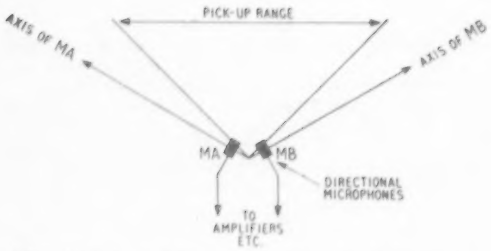


Fig. 11. Stereophonic sound pick-up using directional microphones.

A somewhat similar method shown in Fig. 10 has been developed using a flat "shadow disc" between pressure operated microphones which are otherwise close together. The effect of the "shadow" of the disc is again largely influenced by frequency. The system tends to produce excessive differences at high frequencies and inadequate differences at low frequencies.

Directional microphones placed close together as shown in Fig. 11 give the most satisfactory pick-up from the stereophonic point of view.* Unfortunately it is difficult to make a satisfactory microphone with a polar response independent of frequency. Ribbon microphones can be employed, but if these are used with their axes set at 90° the angle of pick-up is limited to about 60° for correct positioning of the sound images. A great advantage obtained by the use of directional microphones over the artificial head and the "shadow board" is their ability to separate the positions of those low frequency sounds that are important in the reproduction of reverberation. This is still valid even if the directional sound pattern of the loudspeakers is not well maintained at the low-frequency end of the sound spectrum.

* G.E.C. system and E.M.I. "Stereosonic" System.

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Transistor Digital Computers

NEW BINARY CIRCUIT TECHNIQUES DESCRIBED AT I.E.E. CONVENTION

WHEN the thermionic valve was introduced into digital computing it made possible machines of remarkable versatility and tremendous speed of operation but also brought with it a number of disadvantages. These were perhaps not obvious in the early days, but now, with hundreds of digital computers being sold as commercial products, they are beginning to make themselves felt a little more.

To begin with, the valve has a certain rate of failure and limitation of life. This may not be very important in a domestic broadcast receiver, but in a digital computer, containing anything between 300 and 3,000 valves, it becomes of considerable nuisance value (a graph in another article in this issue (page 232) gives some idea of how reliability of equipment decreases with number of components). Secondly, when several hundred (or thousand) valves are massed together in a single equipment they generate a great deal of heat, and so threaten the reliability of other components—not to mention the kilowatts of electric power consumed in the process. Thirdly, there is the uneconomical size of valves for digital computing operations; considering that most of them do little more than act as simple two-state elements they take up an unnecessary amount of space.

It is only to be expected, therefore, that alternative devices are being sought that will overcome these particular disadvantages. At the moment there are two principal ones—the transistor and the two-state magnetic core. Both are small and robust, produce very little heat, are efficient in operation and appear to have a long expectation of life (so far as we can tell at present). In addition they will both operate from a single source of power of only a few volts.

The possibilities of these devices, and methods of using them in digital computers, were recently discussed at a highly successful convention on digital computer techniques held by the I.E.E. in London. A whole session, in fact, was given over to "The Transistor." This included papers on two complete transistor digital computers, one built at Manchester University and the other at the Atomic Energy Research Establishment, Harwell, while later on there were papers on special computing circuits using combinations of transistors and magnetic cores.

It was interesting to note that both of the complete machines relied principally on point-contact transistors for the computing circuits, and it seems that these devices are still regarded very highly by the computer people, even though everybody else has virtually dismissed them as obsolete. The properties of the point transistor were, of course, recognized very early on as being suitable for pulse and switching circuits. In the first place there was a good frequency response, and secondly, unlike the junction transistor, a negative resistance characteristic that could be used to give a regenerative change-over action in a two-state circuit (equivalent to the Eccles-Jordan valve trigger commonly used in binary computing).*

Unfortunately the point-contact transistor proved

* See "Transistors—Applications in Trigger Circuits," by Thomas Roddam, *Wireless World*, June, 1953.

to be somewhat unreliable. Apart from its temperature sensitivity, high noise value, general fragility and liability to burn out, it had characteristics which varied widely from unit to unit and this made it difficult to design two-state circuits with consistent "on" and "off" conditions. However, a technique was developed, notably by F. C. Williams, G. B. B. Chaplin and E. H. Cooke-Yarborough, whereby circuits could be designed which were sensibly independent of the individual transistor characteristics. It was not necessary to select the transistors specially nor to adjust the other components according to the different characteristics. This technique consisted of feeding defined currents to the electrodes and involved the use of "catching" diodes and bias supplies to determine the various limiting conditions.

Two-State Pulse Amplifier

Similar methods are, in fact, used in the two complete computers described at the I.E.E. convention. In the Manchester machine the point-contact transistors function principally as pulse amplifiers, while the logical gating operations are done by germanium diodes. The pulse amplifier here is in reality a two-state device with a regenerative switch-over action. It is "set" into the "on" or conducting condition by the incoming digit pulse and "unset" or turned off at the end of each digit period by a regular clock-pulse of 125-kc/s repetition frequency. The output is taken from the collector of the transitor, and has a voltage swing between the defined limits of the "bottomed" condition and a potential at which it is "caught" by a diode. Such two-state circuits are also used in the machine as temporary stores (each circuit storing one digit of a number).

Fig. 1 shows the kind of bi-stable trigger circuit used in the Harwell machine. It is "set" into the conducting condition by discharging rapidly into the emitter a capacitor which forms part of a triggering gate circuit. The triggering pulse causes enough base current to flow to cut off the base-potential "catching" diode momentarily and so raise the base-circuit impedance to a value which produces the desired positive feedback. The regenerative action then takes place and switches the transistor rapidly into the "on" condition. To "unset" the circuit back into the "off" condition a positive pulse is applied to the base of the transistor through the diode shown. The pulse comes from an auxiliary transistor circuit, a mono-stable type, which is actuated by the triggering gate circuit.

The main store of both the computers consists of a magnetic drum. This is basically a slow-access device, but an interesting feature of both machines is that one track of the drum, with its "write" and "read" heads, is used as a quick-access store working on the regenerative delay-line principle.

Another feature of the Harwell computer is a system of interleaving different numbers on the magnetic drum. The arrangement adopted here permits the "reading" of the operands from the drum, the performance of the computing operation and the "writing" of the result back on to the drum all to proceed concurrently. As a result the computing speed of the machine is faster than would normally be possible and this helps to compensate for the slowness of action made necessary by the use of transistors rather than valves.

This slowness of response is, in fact, the main drawback to the use of transistors in digital computers. Whereas in thermionic-valve computers digit-pulse frequencies of 1 or 2 Mc/s are quite normal, with transistors it is difficult to obtain p.r.fs of much above 100 kc/s. A particular problem here is the hole-storage effect caused by the emitter injecting excess holes into the transistor when the collector is in the "bottomed" state (passing no further current). These excess holes cause trouble when an incoming pulse tries to trigger the two-state transistor circuit into the "unset" or non-conducting state, for they produce a continuing current in the collector and as a result the back edge of the output pulse is sloping instead of almost vertical. This, of course, limits the operating p.r.f. of the circuit.

Junction transistors are even less favourable than point transistors in frequency response and consequently have not been used very much in computing circuits. However, the Harwell machine uses some 50 of them in parts of the circuit where the advantages of this kind of device (e.g. low noise) outweigh the poorer frequency response. In the future, of course, when high-frequency junction transistors such as the surface-barrier type become generally available, and the cut-off frequencies are increased to several megacycles, the main limitation of the device in computing circuits will be removed.

One computing application in which the junction transistor is likely to become quite important is the driving of two-state magnetic cores. These cores, which are usually made of ferrite material, are basically storage elements and have hitherto been used for this purpose in storage systems of the matrix type. It now appears that they can also be used as two-state trigger circuits if there is some kind of amplifying device to drive them from one state to the other, and the transistor is the obvious choice for the job. The two states in question are actually conditions of high remanent flux density (almost at saturation point) in the core, and these, and the rapid switch-over from one state to the other, are obtained by virtue of the fact that the core material has an almost rectangular hysteresis loop.

Fig. 2 shows the general principle. Suppose the core is magnetized to saturation in one direction, say to the "1" state, by passing a pulse of current through a winding. At the end of the current pulse the magnetizing field will still be very high—at least 90% of the maximum flux density—thereby retaining the information that the core has been switched into the "1" state. If now another current pulse is passed through another winding so as to apply a magnetizing field in the opposite direction, the

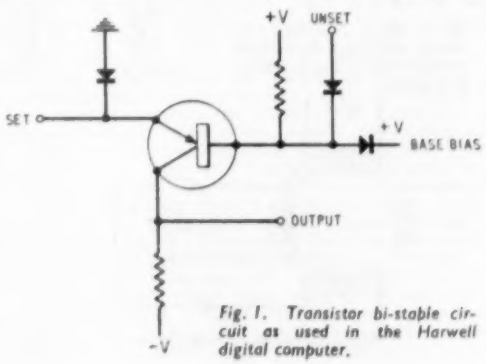


Fig. 1. Transistor bi-stable circuit as used in the Harwell digital computer.

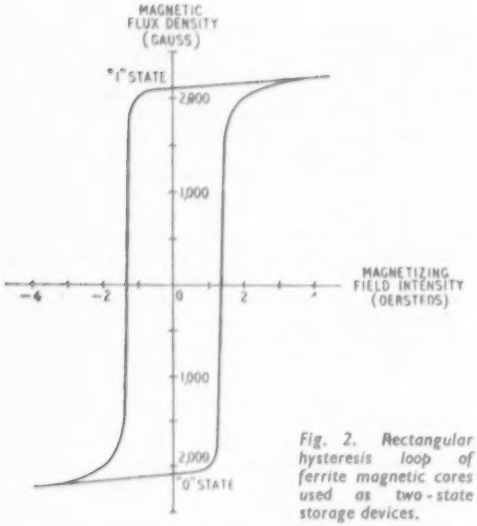


Fig. 2. Rectangular hysteresis loop of ferrite magnetic cores used as two-state storage devices.

magnetic flux will at first decrease slowly then upon reaching the top-left "knee" will suddenly drop to zero and shoot straight up to the opposite saturation point or "0" state. Thus a fairly small increase of magnetizing current will switch the core rapidly from one state to the other, and once the core is in that state it is not critically dependent on the current, which can be reduced to zero without affecting the stored information.

One of the transistor circuits described at the I.E.E. convention in which this type of storage is used is shown in Fig. 3. The basic element consists of one core and one junction transistor, and the core is coupled to the transistor by a winding between base and emitter. Assuming that Core 1 is in the "1" condition and Core 2 is in the "0" condition, a pulse applied to the "unset" winding of Core 1 will change its state and in so doing produce a rapid change of flux which will generate a voltage across the base-emitter winding. This voltage is arranged to drive the base of V_1 negative with respect to the emitter and as a result a considerable current flows in the collector circuit. The collector actually "bottoms" to within a fraction of a volt of the emitter potential, and its current is determined by the resistor and the negative supply. As can be seen, this collector current passes through a winding on Core 2, and the winding is arranged so that it changes the core from the "0" state to the "1" state. Again the transition produces a voltage across the base and emitter of the following transistor (V_2), and this time the base is driven positive and the collector current is switched to almost zero.

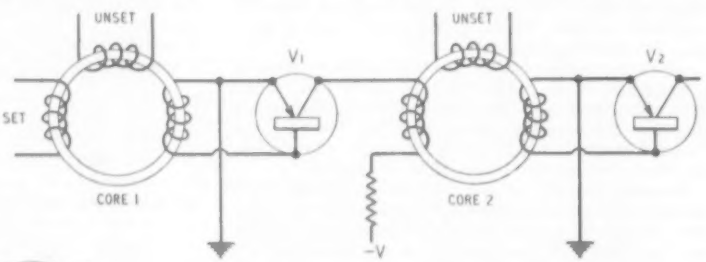
In some equipments this simple type of circuit has been used with the addition of positive feedback or regeneration. As shown in Fig. 4, the output current from the transistor is passed back through an additional winding on its own core before going on to the next core. This additional winding is arranged so that the magnetic field generated is in the right direction to assist the transition from one state to the other which has already started in the core. As a result, once the core is triggered it will change its state, using the current of the associated transistor, even though the triggering pulse of current has ended.

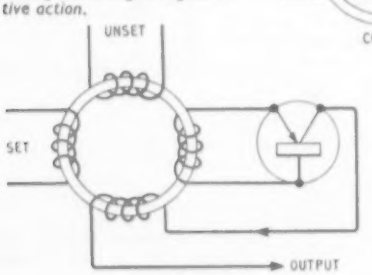
Combined circuits of this kind will work normally at repetition frequencies up to 50 kc/s and, with modifications, up to several hundred kilocycles. The limitation of speed is certainly a drawback but there are a great many attractive features, especially in the regenerative circuit, to compensate for it. In the first place, since the transistor is always cut off except when shifting the core operating point, and since the state of the circuit is maintained purely by the remanent flux, the "standby" power consumption is negligible. Moreover, the input triggering current needed is quite small since it only has to produce a very small change of flux. The circuit permits wide tolerances in component values and transistor characteristics and is consequently very reliable. Finally, the apparatus is extremely small: in one type of computing equipment in which it was used instead of thermionic-valve circuits the overall reduction in size amounted to 100: 1—with, incidentally, a 3000: 1 reduction in power consumption.

One should not assume from all this, of course, that the thermionic valve is likely to disappear quite soon from digital computers. There are a great many difficulties to be overcome in transistor circuits before this happens. Not only are the transistors too slow, but they have not yet reached the stage of offering a definite commercial advantage over valves in computing equipment. However, the developments which are bound to come in the next year or so—improved power ratings, higher operating frequencies and perhaps reduction in price—are likely to make a big difference to this situation.

Right: Fig. 3. Circuit containing two transistor-core elements, the output of one triggering the other.

Below: Fig. 4. Transistor-core circuit with positive feedback arrangement to give regenerative action.





LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by his correspondents

F.M. Discriminators

M. G. SCROGGIE'S article in the April issue points out the advantages of the pulse-counting discriminator, but does not in our opinion give sufficient weight to the difficulties of incorporating it in a practical receiver.* To provide adequate selectivity a rather complicated double superhet circuit is necessary. The alternative—direct conversion to the low intermediate frequency (say, 200 kc/s) required by the characteristics of the discriminator—leaves the circuit open to second-channel interference.

Suppose the signal to be received is at a frequency of 92 Mc/s. If the oscillator is set to 92.2 Mc/s, a signal at 92.4 Mc/s will be received almost equally well, since the r.f. circuits would not provide any substantial attenuation; in fact, signals anywhere in the range about 92 Mc/s might "capture" the receiver. For example, a signal at 91.8 Mc/s or at 92.6 Mc/s would produce an input to the detector at 400 kc/s which would probably lie within the passband. We received a report of a receiver of this type in which interference occurred on the Wrotham Home Service from the Third Programme separated by a frequency difference of 2.2 Mc/s! Ideally, of course, the passband should be just sufficient to accommodate the signal, e.g., 100-300 kc/s. However, the attainment of substantially uniform gain/frequency and linear phase shift/frequency characteristic in this band, with adequate rejection at frequencies adjacent, is likely to be difficult. Even if this were done, there would still be no second-channel protection, and each signal would be received at two settings of the receiver tuning control.

The distortion figures quoted indicated that something less than 1 per cent might be expected. We feel that it should be pointed out that similarly low figures can be obtained consistently with a Foster-Seeley type of discriminator (see, for example, J. G. Spencer; *Wireless World*, December, 1952). The figure quoted by ourselves in the April, 1955, issue for a ratio detector, 3 per cent maximum, is typical for this form of detector. It must be emphasized that the distortion figures quoted are in all cases at maximum output only. By accepting a reduced efficiency, it is possible to reduce the distortion associated with a ratio detector to a very low level.

S. W. AMOS, G. G. JOHNSTONE.

London, W.9.

* No doubt the author will remedy this deficiency when fulfilling his promise to describe a practical receiver in a forthcoming issue.—ED.

B.B.C. Publicity Wanted

MAY I use your columns to reinforce a personal plea put forward by me at a recent meeting of the Radio Industries Club?

In spite of the excellent relations existing between the industry and the B.B.C., radio and radio-like products do not enjoy the amount of broadcast publicity that is regularly accorded, for example, to motor cars, household appliances and books. Surely it is not too much to ask for that the preview of the National Radio Exhibition should be given at least as much programme time on television as, say, the Ideal Home Exhibition.

As things are, little is done by the B.B.C. to inculcate in the public an intelligent interest in sound and television receivers, to say nothing of such domestic sound reproducing equipment as tape recorders and record players.

I suggest that series of programmes on both sound and television should be given in which, for example, the advantages of different types of television receivers could be discussed. The pros and cons of 14-in, 17-in and 21-in screens; the advantages and disadvantages of console and table models; the advisability or not of incorporating a v.h.f. receiver in a television cabinet, are all points which could receive attention.

Possibly a series of programmes devoted to the products of the radio industry could be given, somewhat on the same lines of those which were transmitted recently in regard to the automobile industry.

The advantages of v.h.f. broadcasting might also be hammered home more fully. It seems clear that the majority of the non-technical general public do not really know that it exists. The fact that the areas in which v.h.f. broadcasts can be received coincide with some of the areas served by the television transmitters would presumably make it comparatively easy for a series of television programmes on v.h.f. broadcasting to be transmitted in those areas where the v.h.f. service is already in operation.

Car radio, too, could be encouraged; that, incidentally, would bring extra revenue to the B.B.C., and ultimately, there might be special programmes for car radio users.

Hemel Hempstead, Herts. RICHARD ARBIB.

Receiver Design

"DIALIST'S" paragraph in the October issue stating that he will be seeking a first-class v.h.f. receiver when f.m. transmissions commence in his area touches a very sore spot.

At an ever-increasing rate for the past three years there have appeared published designs, v.h.f. kits and sets for sale by the dozen, all with that primitive perpetration, continuous tuning. Two outstanding exceptions (both factory built) up to date enough to incorporate pre-set switched tuning prove that the difficulties are not insuperable. In these days of electronic miracles continuous tuning for the three locals is just not good enough.

When v.h.f. comes my way I shall have switch-tuning for the Third, Home and Light programmes, even if it means retaining my existing a.m. equipment.

Chasetown, Staffs. STANLEY MAY.

Technical Training

THE recent outcry at the lack of scientists and technicians prompts me to voice my own personal experiences in the almost impossible task of finding suitable technical instruction.

I endeavoured to study for the City and Guilds full technological certificate in telecommunication engineering. The nearest suitable institute is situated twenty miles away and necessitates a tedious two-hour journey to attend. I am, however, willing to undertake this for three evenings a week in order to attend classes.

When I approached the authorities three years ago I was informed that I must start at the beginning of the course even though my home study would see me through the first two years. Result: two wasted years sitting in classes writing elementary notes that I knew from A to Z. Now, after having obtained at great waste of time the necessary slips of yellow paper for an intermediate certificate, I find I do not qualify as I haven't taken an elementary mathematics examination. This, of course, necessitates attending a suitable course before I am allowed to sit for the examination.

My enquiries for the third year course of instruction drew a complete blank. There were insufficient students enrolled to form a class. The alternative that I was offered was a five-year course leading to a Higher National Certificate in electrical engineering. But, I

was informed, this would of course necessitate my starting at the beginning before I could sit for any of the examinations! Another two or three wasted years.

The alternative is, I suppose, the not very satisfactory correspondence course, the price of which, even on the instalment plan, is beyond my compass. Why not therefore relax the awkward rule that insists on attendance on a recognized course of instruction and let the "home study" students take their place in the examination room. The worst that they can do is fail.

I shall enquire again next year for the course that I desire to take, but I am certain what the answer will be. Meanwhile, when scanning the "Sits. Vac." columns I will continue to kick my heels in frustration through banging my head against the same old brick wall.

Does anyone want a good right arm in exchange for the rest of the course on which I have set my heart?

Faversham, Kent. S. J. COE.

Flywheel Sync

AS an engineer with a little experience of television it is inevitable that friends contemplating the purchase of a television receiver ask my advice. This has happened on numerous occasions since the opening of the Norwich transmitter and I have always confined any advice to expressing certain design features I personally would wish to be incorporated in the receiver. One such feature I always mention as being highly desirable is flywheel synchronization or horizontal a.f.c. But it appears I must be wrong. Or am I?

Without exception, the prospective customer has approached the dealer and immediately this feature is mentioned every argument against it has been brought forward; every possible reason imaginable being used to convince the now not-so-sure customer that flywheel sync is not only unnecessary, but even undesirable.

Can someone explain this apparent paradox?

Norwich. R. WILLIAMSON.

Print-through or Pre-echo?

THE "pre-echo" which R. C. Bell has noticed (March issue) on some long-playing and standard discs is not due to print-through on the magnetic tapes used for the recording but is an inherent fault in the cutting of a disc.

As the groove is cut a small mound is formed on each side and this tends to displace the adjacent groove. In effect, any large-amplitude signal is superimposed, much attenuated, on to the previous groove.

The modern method of disc recording is to record as high a signal level as possible and as many records begin at a high level this "pre-echo" can be easily heard.

London, E.15. J. MOSS.

"*Loudspeaker Enclosure Design*"

I REFER to the second part of the article on this subject in *Wireless World*, February, 1956.

Since this enclosure is a bass reflex with an acoustical resistance loading the port, I must question the validity of the impedance curves on page 79. These curves and comments on page 77 purport to show that the upper resonance f_2 and the anti-resonance f_r have been reduced to negligible proportions, whilst the lowest resonance f_1 remained virtually unchanged. That this is a physical impossibility can be readily seen by analysing the complete analogue of the system as shown in Fig. 12, page 77. The addition of an acoustical resistance of proportions such that the impedance peak at f_r becomes reduced to negligible proportions would completely eliminate the impedance peak at f_1 regardless of the values of the port mass reactance and volume stiffness reactance.

The velocity in the port mesh and, therefore, radiation decreases rapidly as the resonant frequency f_a is approached. Since the velocity in the port mesh would be greatest in the region of f_1, the addition of an acoustical resistance would have its greatest effect at f_1 and not at f_2. Mr. Jordan cannot validate his statements by claiming that the two resonances are interchanged with respect to those in a bass reflex design where f_a is below the free-air resonance of the cone.

Since the lowest resonance is governed by the mass reactance of the port and the stiffness reactance of the cone suspension, it is impossible to interchange f_1 and f_2 regardless of the placement of f_a.

Jensen Manufacturing Company, Chicago. J. F. NOVAK.

The author replies

I AM indebted to J. F. Novak for his remarks and regret that certain of my arguments may not have been perfectly clear. The following notes are offered to amend this:—

It is incorrect to say that the "Axiom" enclosures are of the bass reflex variety with an acoustical resistance loading the port. The port is formed by the small opening in the centre of the resistive material in the "Acoustical Resistance Unit." This port contains no acoustical resistance other than the viscous resistance that occurs at its edges. The resistive material should be considered as being quite separate from the port, the two being combined in the "Acoustical Resistance Unit" only for practical convenience. I would like to stress that when referring to the port I am not referring to the relatively large aperture into which the "Acoustical Resistance Unit" fits. The "Axiom" enclosure is not a bass reflex enclosure since, by definition, we understand the latter to be an enclosure which will change the phase of the radiation from the rear of the cone and emit it as *useful radiation* from a port having dimensions comparable to those of the loudspeaker cone. Further, for optimum results, it is usual to arrange for the resonant frequency of a bass reflex enclosure to coincide with the free-air resonance of the cone, thereby providing maximum damping at this frequency. The "Axiom" enclosures do not conform to either of these requirements.

Mr. Novak states that it is physically impossible to reduce the amplitude of the upper resonance to a greater extent than the lower resonance f_1. The mechanism of this is fully described on pages 77 and 78 of the February issue, and may be summarized in the following way. Let f_a be the resonant frequency of the parallel section only. Below f_a this section behaves as a mass reactance and above f_a as a stiffness reactance, which added to the series section will produce the two resonances f_1 and f_2 respectively. Now if we make the resonance of the parallel section only (f_a) occur at a higher frequency than that of the series only (free-air cone resonance), then it can be seen from Fig. 13 that the reactance of an f_2 is much higher than an f_1. Since R_r is in parallel with the reactance due to the enclosure, the Q of this will be lower at f_2 than at f_1. The text takes this a stage further and, by translating the effective parallel section into an equivalent series circuit, gives simple proof that the total circuit Q at f_2 may be considerably less than at f_1.

The second argument against Mr. Novak's statement that this is a physical impossibility may be found in the fact that it works, and may readily be shown to do so not only by measurements on an enclosure but also by measurements on an actual electrical circuit made to conform to Fig. 12.

In the second part of his letter Mr. Novak states that the velocity in the port would be greatest in the region of f_1. This is not true since the maximum velocity at the port of any vented enclosure occurs at the resonant frequency of the enclosure. Bearing in mind that the port is the actual open area in the centre of the A.R.U., maximum velocity occurs in this opening at f_a. If we incorrectly regard the entire aperture containing the A.R.U. as the port, then maximum velocity would occur here at some very much higher frequency (i.e., higher than f_a). Maximum velocity could not possibly occur anywhere near the frequency f_1 since this is below f_a.

I do not understand Mr. Novak's remarks regarding the interchange of the two resonances. I have not claimed that this happens and I agree that it does not. So far as I can see this is irrelevant.

Goodmans Industries, Limited, Wembley. E. J. JORDAN.

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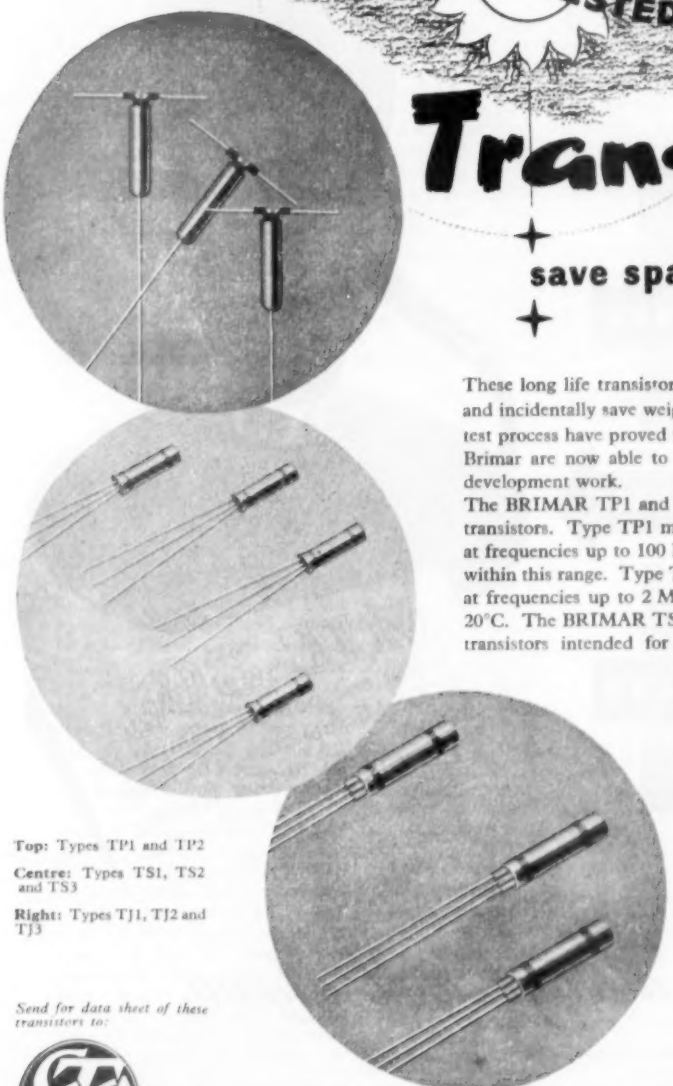

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They are thus immune from the effects of humidity and noxious atmospheric conditions. The small size and low power consumption of these transistors permit the design of light, compact equipment. Since the cases are of metal there is little danger of accidental fracture, and the transistors are also thereby rendered lightproof.

Top: Types TP1 and TP2

Centre: Types TS1, TS2 and TS3

Right: Types TJ1, TJ2 and TJ3

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REPRODUCTION FROM

MAGNETIC TAPE RECORDS

Playback Requirements for Single-channel and "Stereosonic" Tapes

By M. B. MARTIN,* A.M. Brit. I.R.E., and D. L. A. SMITH,* B.Sc. (Eng.), A.M. Brit. I.R.E.

THE development by Electric & Musical Industries, Ltd., of a practical method of making commercial copies of their original master tape recordings opened up new possibilities in the field of very high quality music reproduction.

These single-channel tape records were the forerunners of the fundamental new development of the "Stereosonic" technique of recording and reproduction first announced by "His Master's Voice" in April, 1955.[1] These tape records add a new dimension to recorded and reproduced music, giving a sense of depth, perspective and movement which is not present in single-channel reproduction.

The purpose of this article is to offer some guidance to those who as yet may have had little experience of these records, in the hope that a few pitfalls can be avoided in the design and construction of reproducing equipment.

The standards to which tape records are made have been published;[2] the main factors involved for reproduction purposes are speed, track dimensions and frequency characteristic. The track dimensions

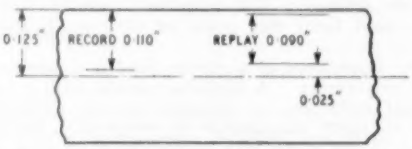


Fig. 1. Track dimensions for half-track recordings.

are given in Fig. 1: a track of 0.110in is recorded on each half of a tape 0.250in wide; in the same figure the recommended replay track width of 0.090in is also shown. The reason for this difference of 0.020in is to prevent modulation of the reproduction by scanning the edge of the recording. The tape speed is 7½in/sec, which speed enables a very nigh standard of reproduction to be obtained with a playing time from a standard 7-in diameter reel, equal to that of a long-playing disc record.

The recordings are so made that when played with the active side of the tape away from the observer and the tape passing from left to right, the upper track should be scanned.

The frequency characteristic has been defined as conforming to that preferred by the Comité Consultatif International des Radiocommunications (C.C.I.R.) for programme interchange. For a tape speed of 7½in/sec this is defined as a bass rise equivalent to that of a series combination of resistance and capacitance with a time constant of 100 μsec, together with high-frequency lift to compensate for replay head losses.

The distortion content of a tape record is extremely low when compared with the output from a gramophone pickup; it is indeed comparable with that of many amplifiers. At peak signal level the harmonic distortion content is about 2 per cent, but a signal 3 dB below peak has a distortion content of 0.4 per cent and at 6 dB down, 0.1 per cent. A curve of distortion against recording level is given in Fig. 2. Even if the recording is occasionally allowed to overload, the result is not as distressing to the ear as is the distortion produced by the excessive levels sometimes found on modern disc records.

The dynamic range of tape records is high and to do them justice a reproducer should have a signal/noise ratio which approaches 60 dB.

The foregoing remarks apply to both single-channel and "Stereosonic" tape records, but with the latter, both recorded tracks are replayed together. The track dimensions are as given above, and when replayed with the tape passing from left to right with the active side away from the observer and the recording in the correct sense, the top track should be reproduced through the left-hand speaker and bottom track through the right-hand. The tracks are so recorded that the reproducing head gaps should be accurately in line: that is the gap of the top track replay head must be *vertically* above that of the bottom head. This point will be taken up further when we deal with heads in detail.

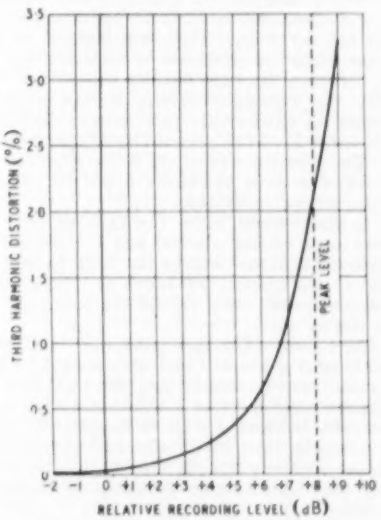


Fig. 2. Distortion plotted against recording level for a high-coercivity tape.

* E.M.I Sales and Service, Ltd.

[1] *Wireless World*, May 1955, p. 202.

[2] *Wireless World*, October 1954, p. 512.

The results obtained when reproducing tape records depend to a very large degree upon the performance of the tape transport mechanism. The three main aspects of this are the speed constancy, spooling performance and the arrangement of the guides and pressure pads.

Speed Variation. The wow and flutter produced by a suitable mechanism should be no greater than that of a first-class transcription-type turntable. That is, the r.m.s. total wow and flutter should be no worse than 0.2 per cent, and preferably better than 0.1 per cent. Unfortunately, tape decks giving a genuine performance of this order at a price which might be considered reasonable for a domestic machine appear to be scarce. The prospective buyer of a given deck is advised to judge for himself by a careful listening test whether the wow and flutter performance will be acceptable to him.

We must also take account of the mean speed measured over a short period—a few seconds to tens of seconds, such as would be indicated stroboscopically or by timing a short tape-run—as distinguished from the overall mean speed, which is simply the quotient of

$$\frac{\text{Full length of tape on spool (inches)}}{\text{Time for complete play (seconds)}}$$

The short-term mean speed of most tape machines varies somewhat from one end of a spool to the other. This variation should not be more than ± 1 per cent of the overall mean speed, which in turn should not differ from the nominal speed by more than ± 1.5 per cent.

Spooling. The tape as spooled by the machine should be evenly wound, no turns of tape should have risen above or fallen below the general level, and the reel of tape should not touch the spool cheeks on either side. The tape tension during the spooling operation should be high enough to enable the wound tape to support itself on the hub alone, be firm enough to be handled without difficulty, even if dropped on a table from the height of a few inches, and be able to resist attempts to push it off the hub. This requirement is most important when the tapes are to be stored for long periods. Again, the tape tension should not be so high that the tape is stretched, as will happen if enthusiasm to achieve the performance laid down above is carried too far. A satisfactory tape tension during the spooling operation is between 80 and 90 gm, for a normal thickness (0.0023in) tape on which the records are made.

The brakes should bring the tape to rest in a minimum time of one second and a maximum of two seconds, without causing the tape to jump or ride out of the guides (or break!). After having been stopped, the tape should be taut, but not excessively so.

The Tape Run.—The tape guides in the tape run over the head and pinch wheel, etc., should be positioned accurately to ensure that the tape lies correctly on the head and that it winds on to the spools symmetrically between the spool flanges. When the tape is running over the heads and guides there must be no tendency for the tape to deform in any way, and there must be no vibration or oscillation of the tape.

Heads.—It should be understood that two replay heads of the same nominal inductance and front gap dimensions, but of different constructions, will in general have different frequency (and sensitivity) characteristics. The "quality" of the front gap, its depth, its relation to the back gap, the iron losses, self-capacitance loss and the condition of the working face must all affect the head's performance; consequently, it is essential to regard a particular manufacturer's head and an associated amplifier as a unit.

For a given tape speed, the ultimate frequency response of the unit depends on the replay head, with the front gap thereof as the most important factor. The edges of the gap must be straight, clearly defined and parallel, whilst the working face of the head should have had imparted to it a high surface finish without impairing the definition of the gap. If, for a tape speed of $7\frac{1}{2}$ in/sec, a response level to 12 kc/s is aimed at, the magnetically-effective length of the replay gap will be about 0.0003in. Anything much greater than this may well lead to trouble with instability of the equalizing amplifier, and in any case will yield a high level of hiss when replaying. As stated earlier, the track width to be scanned is 0.090in; the head should therefore have a "stack" height equal to this.

The laminations should be carefully insulated from each other, and be as thin as possible, in order to reduce high-frequency losses. 0.005in thick Permalloy C is a suitable lamination material, provided that it is carefully and correctly annealed. The dimensions of the working face must be carefully chosen in order to prevent wavelength interference effects in the bass. The principle here is to profile the head in relation to the arc of the tape contact so that the extremes of the arc are not sharply defined. The response obtained with a poor head from this point of view is shown in Fig. 3.

The impedance of a replay head is a matter of some importance. A high-impedance head (about 500 mH inductance or greater) has the advantage that no input transformer is required. Another factor to be taken into consideration is that the self-resonance frequency of the head and input circuit is usually within the frequency range of the machine. This resonance can be used to aid in equalizing for the high-frequency losses, but it is a practice which cannot be recommended, as the variation of inductance from head to head and of stray capacitance of amplifiers will make any attempt at reproducing the results from an experimental amplifier a nearly impossible task. A better system, in any case, is to use a low-impedance head (inductance, a few millihenries) in conjunction with an input transformer.

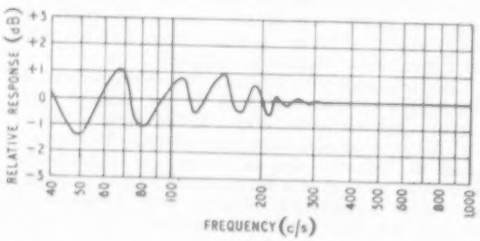


Fig. 3. Replay response from tape, including head, showing interference phenomenon. Tape speed: $7\frac{1}{2}$in sec. Tape with constant current in head. Replay output equalized for normal 6dB/octave rise.

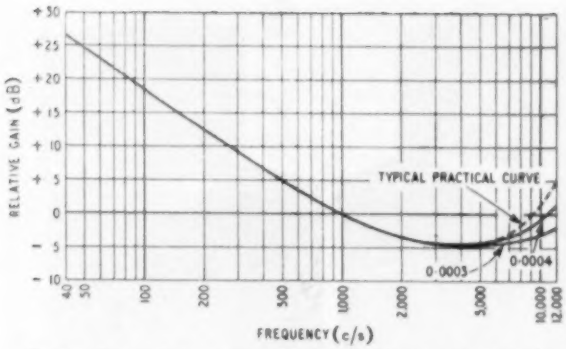


Fig. 4. Replay chain response, 7½in/sec (100 μsec + gap loss).

If the transformer is placed very close to the input grid, the capacitance troubles are minimized and an astatically-wound transformer needs the minimum of screening in order to minimize hum. With a balanced primary winding and a tightly-twisted pair of leads from the head to the transformer, the hum troubles in the primary circuit are small.

The following specification applies to a replay head designed for stereophonic working. It can be regarded as the minimum standard required in order to realize full advantage from both the "Stereosonic" and single-channel tape records.

Mechanical

Track width	0.090in	+0.005in −0.0025in
Track separation	0.050in	+0.0005in −0.000in
Max. permissible lateral gap displacement		0.0005in

Performance

Frequency response (measured at 7½ in/sec with constant record current in a separate record head using a bias amplitude adjusted for maximum playback voltage at 1 kc/s). Playback loss at 12 kc/s relative to playback voltage at 1 kc/s to be not more than −12 dB, allowance being made for record head losses.

Balance between tracks

Sensitivity at 1 kc/s: playback voltage from each track to agree within ±1 dB.

Frequency response: playback voltage at 12 kc/s relative to playback voltage at 1 kc/s to agree within ±1 dB.

Front gap alignment: when the azimuth is adjusted for maximum output from one track at 12 kc/s the loss due to misalignment of the second track to be less than 1 dB at 12 kc/s.

Cross talk

When replaying a half-track recording at 2 per cent distortion level (track spacing 0.030in), the cross-talk generated in the head section scanning the unrecorded track to be less than −50 dB at 10 kc/s.

The comparatively high figure of cross-talk rejection is not necessary for satisfactory "Stereosonic" reproduction, about 35 dB would be sufficient; however, the machine should be capable of playing single-channel tape records, and for this purpose −50 dB cross-talk is just satisfactory (60 dB rejection is necessary if full use is to be made of the dynamic range of the tape). The 60 dB degree of rejection is extremely difficult to achieve in the head alone, whilst a figure of 55 dB can be reached only by rather unconventional head construction and multiple, inter-track screens of Mumetal and copper.

Amplifiers

The requirements of a pre-amplifier for tape records are low noise and hum levels, low distortion, and careful equalizer design. These requirements are no different from those of any other pre-amplifier, but the signal at the first grid is unlikely to be in excess of 10 mV at 1 kc/s; thus a signal-to-hum ratio of 60 dB involves very careful design. With the 100 μsec bass rise, the lift between 1 kc/s and 50 c/s is nearly 25 dB, hence the signal available at 50 c/s is about 600 μV, and to achieve 60 dB signal-to-noise ratio the equivalent hum at the grid of the first stage can be no greater than 0.6 μV, which implies the use of a hum-bucking arrangement, even when the input valve is of the Z729 type.

The curves in Fig. 4 give typical pre-amplifier responses for heads with effective replay gaps of 0.004in and 0.0003in. The precise amplifier response in the high-frequency region depends also upon the head losses other than the gap loss. That is, the curves of Fig. 4 indicate the minimum h.f. response required for heads of the quoted effective gaps. A typical working curve is shown as a dotted line. Final adjustment of response is most readily carried out by playing a standard frequency test tape. It will also be found that the low-frequency output from certain types of replay head is somewhat (one or two dB) greater than would be expected if the l.f. output is assumed to be proportional to frequency.

The amplifier should be so designed that there is no danger of oscillation at the peak frequency of the equalizer lift and that the non-linear distortion introduced by the method of lifting is negligible.

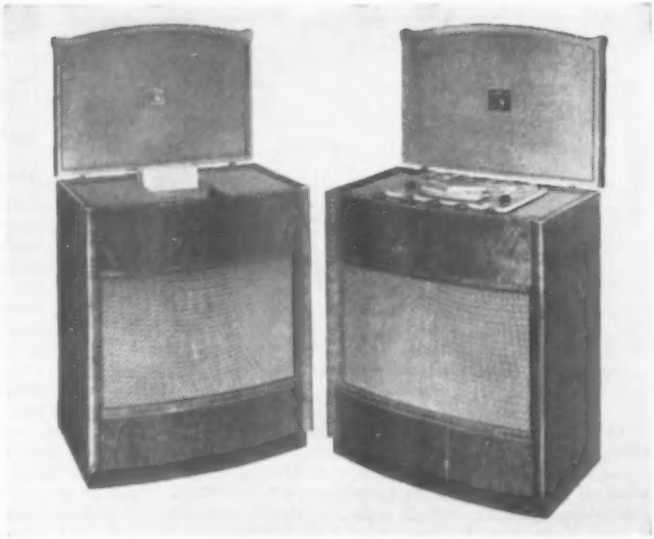
For "Stereosonic" reproduction, it is advisable that the gains of the pre-amplifiers should be individually variable to enable the residual differences in head sensitivity and amplifier gains to be removed in the setting-up process. The high-frequency equalizers should be variable so that the slight difference in head responses can be accounted for. It is also an advantage if the output stage is a cathode follower or some other low-impedance circuit, in order that power amplifiers can be fed through unequal lengths of cable if necessary, without the risk of the magnitudes of the outputs becoming unbalanced or of hum pick-up taking place.

The power amplifiers should introduce very little distortion, a figure of 0.25 per cent max. is typical, and the frequency range at full rated power should be 30 c/s to 12 or 15 kc/s. For "Stereosonic" equipment, the gains of the power amplifiers should be accurately matched: a satisfactory method of achieving this is to use a high degree of feedback with close-tolerance high-stability resistors in the feedback loop. A gain match of less than 0.5 dB is necessary and can be achieved in this way.

In both power and pre-amplifiers, care should be taken to avoid uncontrolled phase shifts within the

working frequency range. Tone and gain controls, etc., should produce identical effects in both channels. For convenience in operation, such controls may be ganged. However, the resistance/rotation laws of a normal commercial-grade potentiometer are not claimed to be matched to within the 5 per cent required by a twin-channel system. The preferred arrangement is the use of switched controls with the resistance elements if possible of a high-stability type.

In some rooms, it may be necessary to correct electrically for acoustic unbalance, which causes a lateral shift of the sound image. Adequate correction can be made by raising the gain of one channel relative to the other. For a permanent installation, this can be done "once-and-for-all" when the equipment is set up. Otherwise, a differential gain control between channels should be provided.



H.M.V. Model 3034 "Stereosonic" reproducing equipment in its latest form.

"Stereosonic" Reproducers

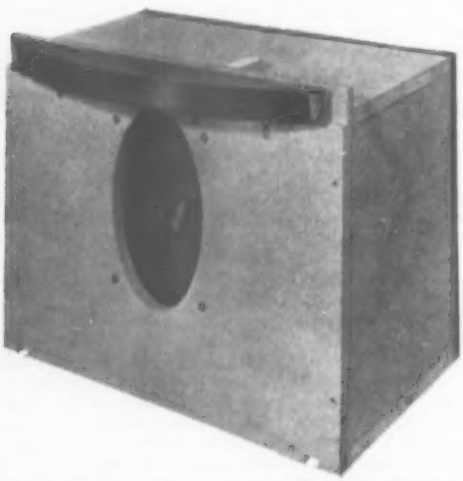
The final result from a "Stereosonic" reproducer can be spoilt by a careless choice of loudspeakers, however carefully the amplifiers and head are designed and made. The loudspeakers used should have closely matched responses and sensitivities. If one loudspeaker has a peak at say 8 kc/s which is absent from the other, this can have the distressing effect of divorcing a singer's voice from its sibilants. The singer then appears to be standing in the centre, say, with all the sibilance appearing to come from a point a foot or two away! The polar diagram of the loudspeakers should ideally be as nearly semicircular in the horizontal plane as possible. Fortunately, the advent of electrostatic loudspeakers has helped considerably at the high frequencies. The "beamed top" often associated with high-quality loudspeakers can cause a distinct loss in the effective sound image when compared with a speaker with an even distribution.

It may also be found to be an advantage if the back radiation of the loudspeaker is limited. In certain types of room the acoustic loading of the room on the backs of the bass speaker cones can cause unbalance in the low-frequency end. Fortunately, the majority of high-quality bass enclosures have very little back radiation.

Our experiments have shown that a high standard of "Stereosonic" reproduction can readily be achieved in domestic conditions, from rooms as small as 9ft × 11ft to the baronial hall; in fact, we have not yet found a domestic type of room in which good results cannot be readily obtained.

These experiments were carried out using the prototype of the Model 3034 H.M.V. "Stereosonic" reproducer, which has been designed according to the principles outlined. The pre-amplifiers have pre-set gain controls variable over about 6 dB to facilitate the balancing procedure, and the equalizers are variable as outlined above. The volume, bass and treble controls are ganged; they are step controls using high stability resistors, the volume control being graded in ten steps; the difference in gain between the two channels on any position of the controls is not greater than 0.5 dB. The other two controls on the top panel are a system switch giving "Stereosonic," "Single-channel tape," a "Single-channel auxiliary" input and the "Balance" control; this is a differential gain control (in the single-channel positions the inputs to the two power amplifiers are in parallel). On the rear of the control console there is a switch which reverses the two channel feeds to the loudspeakers, so that the control console can be placed on either side of the second cabinet.

In the photograph of a loudspeaker unit the long bowed electrostatic speaker which operates from 5 kc/s upwards can be seen at the top. The bass unit is an elliptical speaker enclosed in an airtight



Loudspeaker assembly comprising an elliptical moving-coil and a high-frequency electrostatic unit.

box of 3.5 cu ft, the system being critically damped with a system resonance between 45 and 50 c/s (on an open baffle the speaker resonance is 22 c/s). The power amplifier driving this loudspeaker system is push-pull, delivering 10 watts to the bass unit, with a side amplifier delivering 140 V r.m.s. to the electrostatic speaker. There is an overall negative feedback loop of 26 dB, the resistors in this loop being high stability type with a close tolerance in order to ensure that the gain of all production amplifiers is held within 0.5 dB of standard. The frequency response of the system is unusually smooth from 40 c/s to 16 kc/s, with a polar response which is substantially semi-circular up to 10 kc/s; the deviations above this frequency are slight.

In conclusion, we would say that given the necessary recordings, "Stereosonic" reproduction is not as difficult as it may sound, provided that the choice of heads, loudspeakers and amplifiers is made with the factors mentioned above in mind.

Finally, the authors would like to thank the British Institution of Radio Engineers for permission to use much information which was contained in a paper presented by the authors to the Institution on 5th January, 1956, and published in the —*Journal Brit.I.R.E.*, Vol. 16, No. 2, February, 1956.

Frequency Stabilization of Oscillators

By V. N. GRAY, B.Sc.,*

Negative Temperature Coefficient Capacitors as Correcting Elements

IT is well known that the frequency of an oscillator changes with temperature and that it can cause distortion and loss of signal strength in an f.m. or television receiver.

The inductance of a coil varies with temperature; this is brought about by dimensional changes and also to changes in the current distribution in the wire. The latter is caused by variations in skin and proximity effects as the wire resistance changes. Dimensional changes with temperature depend on a number of factors. If a coil could be freely suspended, its temperature coefficient would be the same as the temperature coefficient or linear expansion of the wire. Since the coil must have fairly rigid connections, even if not suspended by other means, mechanical strains cause added changes in dimensions so that the resultant temperature coefficient may be several times that of the linear expansion of the wire. The contribution to the temperature coefficient due to resistance changes is small at low and very high frequencies when the skin and proximity effects are respectively small and very large. At frequencies of the order used in v.h.f. broadcasting and television where skin and proximity effects are moderate, the temperature coefficient of resistance of the wire has its greatest effect. Thus an accepted value for the temperature coefficient of inductance of an open-wound coil is of the order of +120 parts per million per degree centigrade. When the coil is wound on a former, such as in an i.f. transformer, this value may be reduced to about +100 p.p.m. per °C.

The temperature coefficient of capacitance for a silvered mica capacitor may vary from zero to about +60 p.p.m. per °C, this being almost entirely due to change in dimensions. Values up to +150 p.p.m. per °C have been quoted for the temperature coefficient of air-dielectric trimmer capacitors, caused by linear expansions of the plates, bending of the plates due to different linear expansions of different parts of the assembly, and deformations due to residual stress changes.

The stray capacitance has a temperature coefficient of similar order to that of an air-dielectric trimmer, so that in the oscillator circuit of a v.h.f. receiver, where the tuning capacitance usually consists of stray capacitance and a trimmer, the resultant temperature coefficient is of the order of +150 p.p.m. per °C, while in an i.f. circuit it would be about +100 p.p.m. per °C.

Let us take the case of a Band II f.m. receiver, operating at approximately 90 Mc/s. If the oscillator were on the high side, its frequency would be approximately 100 Mc/s. (The usual value for the intermediate frequency is 10.7 Mc/s.)

In the oscillator circuit the combination of capacitance and inductance change may, in the worst cases, amount to +270 p.p.m./°C which corresponds to a frequency change of −140 p.p.m./°C:—

Using $f = \dfrac{1}{2\pi\sqrt{LC}}$

The new frequency f'

$$= \frac{1}{2\pi\sqrt{[LC\,(1+150\times10^{-6})\,(1+120\times10^{-6})]}}$$

$$= \frac{1}{2\pi\sqrt{[LC\,(1+270\times10^{-6}+\ldots.)]}}$$

neglecting the last term in the expansion.

Then

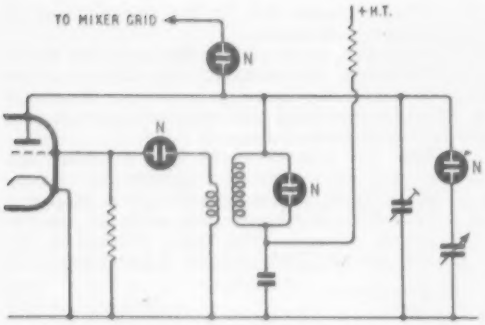
$$f-f' = \frac{1}{2\pi\sqrt{LC}} \times \left[1-\sqrt{\frac{1}{1.00027}}\right]$$

$$\approx \frac{1}{2\pi\sqrt{LC}} \times 0.00014.$$

This would mean a frequency change of -140×100 c/s, i.e. −14 kc/s, in the oscillator for each °C change in temperature. Over an extreme range, from the "cold set/cold room" conditions (10°C) to "warm set/warm room" state (40° C), the frequency drift is thus -30×14 kc/s, i.e. −420 kc/s.

Likewise, an i.f. circuit, having temperature coefficients of inductance of +100 p.p.m./°C and of capacitance of about +50 p.p.m./°C (correspond-

*A. H. Hunt (Capacitors) Ltd.



Some of the positions in an oscillator circuit where a negative-temperature-coefficient capacitor might be used are shown here marked "N." One or two positions only so equipped might serve in some cases.

ing to a temperature coefficient of -75 p.p.m./°C), will drift $-30\times75\times10$ c/s, i.e., $-22{,}500$ c/s approximately. Since this change is in the same direction as the change in oscillator frequency, the overall difference in tuning frequencies between the two conditions is some 400 kc/s. When this figure is compared with the 180 kc/s bandwidth for the i.f. channel of an f.m. receiver, it may easily be appreciated that severe distortion will occur due to non-operation of the limiter and incorrect operation of the discriminator (or ratio detector), even if the signal is not completely lost during the warming-up period.

Fortunately this effect may be overcome by the use of negative-temperature coefficient capacitors. There is generally no point in putting a correction capacitor in both oscillator and i.f. circuits and it is usual to design the oscillator circuit to have approximately the same drift as the i.f. amplifier. In the case we have cited, the oscillator circuit should be arranged to have a small negative-temperature drift of $\frac{22.5}{30}$ kc/s/°C; i.e., a coefficient of $\frac{22.5\times10^3}{30\times100}$ p.p.m./°C, which is $+7.5$ p.p.m./°C. The LC product must, therefore, have a final coefficient of $+15$ p.p.m./°C. (If the oscillator frequency were below the signal frequency these signs would be reversed.) Since we quoted a temperature coefficient of inductance of $+120$ p.p.m./°C for the inductance, the capacitors (including strays) must have a temperature coefficient of -105 p.p.m./°C. If the total capacitance in the circuit (including valve and other strays) is C and the negative coefficient part (of say -750 p.p.m./°C) is c then

$$-105\,C = -750\,c + 150\,(C - c)$$

$$c = \frac{255}{900}\,C$$

$$= 0.283\,C.$$

Values for the "accessible" capacitance in oscillator circuits for typical (including home-constructed) receivers vary from about 25 pF upwards, depending, naturally on the coil and the type of circuit used.

Since the lowest value capacitor having a negative-temperature coefficient of 750 p.p.m./°C usually quoted by manufacturers is 10 pF, it would seem that a total circuit capacitance (including strays) of some 35 pF is indicated. This is not an unreasonably large value, but since the values for temperature coefficients quoted above are likely to be on the upper limit of those encountered in practice, it might become necessary to use the correction capacitor across a part only of the coil.

Another possibility might be to use the negative-temperature-coefficient capacitor as the whole, or part of, the coupling capacitor to the valve, thereby putting it in series with a high proportion of the stray capacitance, so that the temperature coefficient of the combination becomes negative in the right proportion to compensate for the remainder of the circuit. One point, which would have to be watched here, is that the oscillator must then have plenty of drive in hand. Such an arrangement used with a circuit which is only just oscillating might cause the oscillations to cease when the value of the coupling capacitor falls with temperature rise! Some of the positions in an oscillator circuit where a negative-temperature capacitor might be used for frequency stabilization are indicated by an "N" in the accompanying circuit diagram.

Naturally this capacitor should be mounted where its temperature is likely to be an average between the coil temperatures and the temperature attained by the valveholder and other strays. Again it should not be fitted close to a wirewound resistor or other heat-dissipating element, nor near a hole in the chassis, where local draughts, hot or cold, could affect its temperature rise considerably.

He would indeed be a lucky person who managed to find the right value for the correction capacitor and its right position first time, because local temperature variations, uncertainty of true temperature coefficients of stray capacities and a tolerance in the temperature coefficient of the correction capacitors, all tend to work against the experimenter. For those people, however, who would have a life of ease in not having to retune their receivers after the warming-up period, or those who aspire to push-button tuning on v.h.f. receivers, some simple experiments are indicated.

Naturally, these experiments are likely to be a little tedious if perfection is to be attained, due to the temperature and time cycles involved, but the fitting of a suitable value correction capacitor, deduced as above, should take care of most of the drift. It is important, if a trial is made, that the receiver should be completely reassembled, even to the back of the cabinet being fitted, as otherwise one cannot be sure that true warm-working conditions are achieved. Again, if the first trial is not too successful, the experimenter should note whether the necessary retuning is still in the same direction, as over-correction is possible.

"TRADER" YEAR BOOK

A VALUABLE new feature of the 1956 edition of the "Wireless and Electrical Trader Year Book" is a very comprehensive table of television receiver i.fs. and sideband characteristics of superhet and t.r.f. models. Other features include a list of i.fs. of sound receivers marketed in the past eight years; condensed specifications of nearly 250 current television receivers and over 400 sound receivers; and base diagrams and connections for some 300 current valves and c.r. tubes. The usual directories of manufacturers, wholesalers, trade names and a buyers' guide are also to be found within the 344 pages of the Trader Year Book. Published by the Trader Publishing Co., Ltd., Dorset House, Stamford Street, London, S.E.1, it costs 12s 6d (postage 1s).

WEIGHING THE BALANCE

Now that the novelty of commercial television is wearing off for a considerable number of people, we are becoming aware that many viewers find that the lack of a balanced picture is a nuisance. They want to be able to switch straight from BBC to ITA and back again without fiddling with the controls.

But how often is an installation left in such a state? Surely the installation engineer should appreciate this need, and he should arrange that his aerials are chosen and sited with this in mind.

Discrepancy between the signals may have a number of causes. Firstly, as the sensitivity of an aerial is proportional to its physical dimensions, the band III aerial must normally have a greater number of elements. Also the receiver and valves are seldom so efficient on band III as on band I.

Modern receivers have automatic gain control (A.G.C.), but considerably more than half those in use were sold before this feature was perfected. There are probably more receivers in the north without A.G.C. than in the south because the northern BBC stations opened more recently and the sets were not old enough to be replaced when ITA came on, and consequently were converted.

The average A.G.C. range of a receiver is limited by design and, where present, provides automatic control over a range from 20 to 40 decibels. If the signal varies outside these limits, manual adjustments have to be made. The receiver should be left so that the input is within the A.G.C. limits and this can only be achieved by a careful choice of aerials, combined with the judicious use of attenuators in the lead carrying the highest input.

" Belling-Lee " have often said that a receiver is just as good as its aerial. We must amend that to include the whole installation —aerials to provide a truly adequate signal, attenuators where necessary, and a suitable diplexer.

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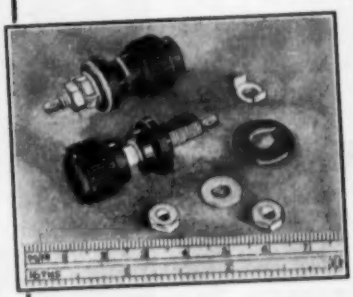
Written 18th April, 1956

"BELLING-LEE" TERMINALS

'B' TYPE STANDARD L1001 Series

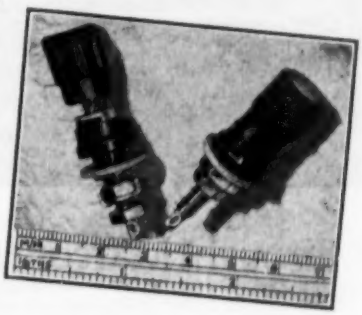


Supplied with black or red non-rotating tops with hot-printed lettering indications if required. Four additional colours are available for phase indication and general identification purposes, i.e., white, yellow, green and blue. Head and collar are insulated and are moulded in a phenolic material. Collar has anti-twist wedge to prevent rotation and possible damage to connections. 2 BA stud is nickel plated with threadless clamping gap. Tin-dipped solder spill with 0.089 in. hole together with specially eared washer for alternative connections. Insulation washer provided.

'W' TYPE L505/10

Where panel space is limited, this compact terminal is very useful. The head is moulded from phenolic material and is non-removable. The nickel plated stud is 2 BA with tin-dipped solder spill.

Rated for 15 amp : voltage proof to 0.064 in. (max.) chassis, 2.5 k Vpeak. (Working voltage to 0.064 in. chassis, 750 volts peak).



★ *We make many types of terminals—those shown are only indicative of our extensive range.*

'H' TYPE L1005

This is a robust terminal, similar to the "B" type referred to above. It is suitable for transmitting sets, charging boards and similar equipment. The head incorporates a black or red non-rotating disc which can be hot-printed with "±" indications if required. Four other colours are available for identification purposes.

Rated for 100 amp : voltage proof to 0.125 in. (max.) chassis, 4 kV peak. (Working voltage to 0.125 in. chassis, 1.5 kV peak.)

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FURTHER NOTES ON THE

Simplified Band III Convertor

CONSTRUCTIONAL DETAILS OF FIXED-TUNED AERIAL FILTER

By O. E. DZIERZYNSKI

AT the end of the article in the March issue describing the Simplified Band III Convertor it was stated that work was in hand on a new aerial filter which would require no alignment. This was to be achieved by using fixed values of inductance and fixed capacitors. The new filter is now completed and is shown here in the illustrations and its circuit, which is theoretically the same as that used for the original tunable filter, is repeated for convenience in Fig. 1. The only significant differences are slightly modified capacitor values to bring them, where practicable, to the 10% tolerance preferred values. The coil numbering is the same as the original and so an L_1 will not be found in this article. It was not practicable to retain the same capacitor numbering.

Physically the filter is quite different, the fixed-tuned filter being built into a screening case measuring only $\frac{7}{8}$in square by $2\frac{3}{8}$in high. This miniaturization, as it might be called, may tax the skill of some potential constructors but any trouble entailed will be well repaid as no precise measurements or adjustments are involved and, furthermore, the new filter has an appreciably better performance than the old.

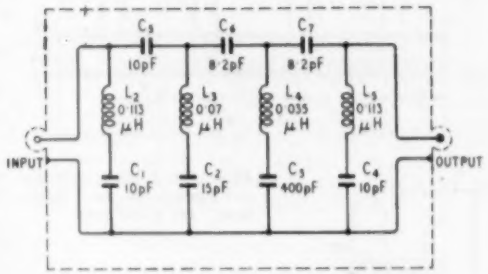


Fig. 1. Theoretical circuit diagram of the fixed-tuned Band III aerial filter. Coil numbers are the same as in the original tunable filter; capacitor numbers are different.

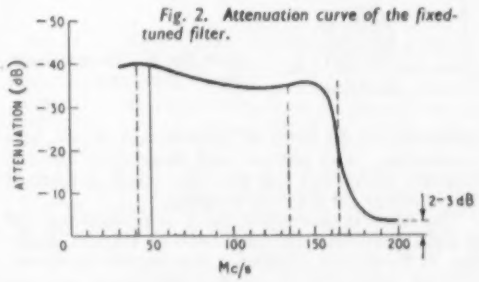
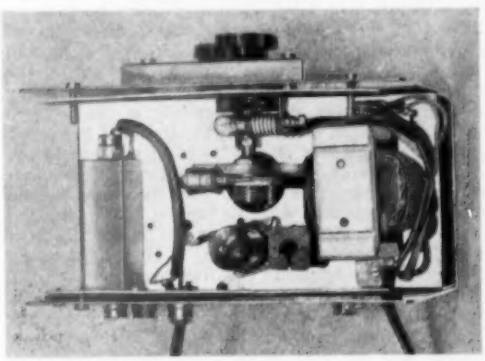


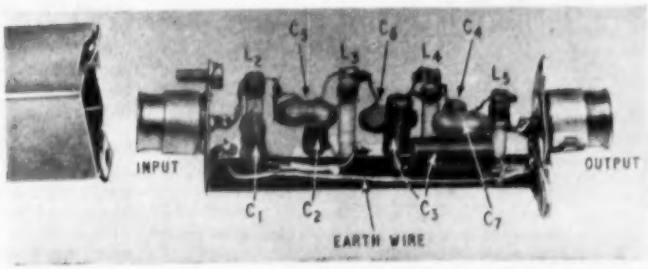
Fig. 2. Attenuation curve of the fixed-tuned filter.



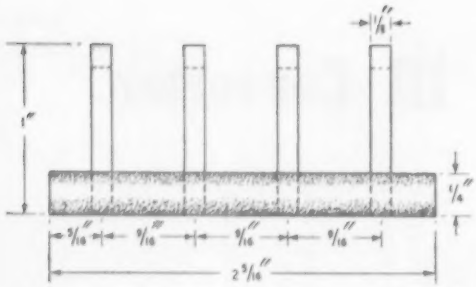
The new filter fitted inside the convertor.

A comparison of the new one's response curve, Fig. 2, with that of the original's (Fig. 4 on page 136 in the March issue) reveals that the attenuation of the new model is maintained reasonably constant at between −35 and −40 dB up to about 150 Mc/s, whereas the earlier model's curve exhibited a marked dip between 50 and 100 Mc/s. The improved performance results from the all-round reduction in size of the filter; miniature capacitors have been used and as they comprise the bulk of the wiring all connecting leads are consequently very much shorter.

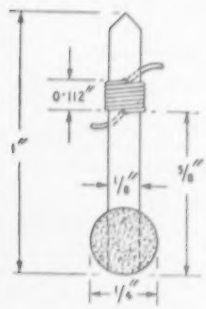
In order to reproduce the performance close



The fixed-tuned filter removed from its can; the annotation conforms to Fig. 1 and enables all components to be identified.



Above: Fig. 3. Spacing of the coil supports on the "backbone" rod of the filter.



Left: Fig. 4. Constructional details of the coils.

adherence to the form of construction shown here is essential. The position and diameter of the coil supports are critical and so is the actual position of the windings on the coil supports.

The filter is assembled on a ¼-in diameter rod of rigid insulating material, such as ebonite, Paxoline, or Erinoid to mention a few suitable materials, and the four coils, L_1 to L_4, are wound on ⅛-in diameter plastic rods (Polystyrene or Nylon) inserted into tightly fitting holes in the ¼-in rod, or "backbone," and spaced along it as shown in Fig. 3.

Winding data for the four coils is given in the coil table and all coils are wound in the same direction with No. 32 s.w.g. enamelled wire and with adjacent turns touching. Each coil should start ⅛in up from the base of the former, as shown in Fig. 4, and the ends of the winding threaded through $\frac{1}{16}$-in diameter holes with about ½in projecting from the opposite side of the coil support to serve as connecting points for the capacitors.

COIL TABLE

Coil	Inductance (μH)	Turns (close wound)	Wire (s.w.g.)	Winding length (in)
L_2 and L_5	0.113	7	No. 32 En	0.112
L_3 ..	0.07	5¼	do.	0.094
L_4 ..	0.035	3¼	do.	0.055

Miniature capacitors must be used in the filter and they can be ceramic, polystyrene or metallized paper types. All, except the largest, C_2, must be under ½in long and not more than ⅜in in diameter, because if they are much larger it will be difficult to pack them into the confined space of the small screening case. The essential thing is that the capacitances be as stated here, the make of capacitor is not important.

The 400-pF capacitor, C_2, while shown in Fig. 1 as a single capacitor, is actually two capacitors connected in series. This value is not a preferred value and so had to be made up by connecting a 500-pF capacitor in series with one of 2,000 pF. If a 400-pF capacitor of a small enough size can be found it will simplify the construction.

In the illustrations both ends of the filter are shown fitted with coaxial sockets and they are secured by 6-BA screws inserted into tapped holes in the ends of the main support, or "backbone." Before fitting the filter in its can the small centre hole usually found in the top of most ¾-in square coil cans must be enlarged to about ½in in order to enable the sleeve of the input coaxial socket, which is the one at the top of the can, to pass through. In addition, two 6-BA clearance holes have to be drilled in the top of the can, on a diagonal and corresponding to the fixing holes in the coaxial socket. A 6-BA screw is soldered into one of the base holes in the socket with its head pointing inwards and the shank outwards so that when the filter is fitted into its can the shank of the screw passes through one of the holes in the top of the can and is secured by a nut and washer. The other 6-BA hole should be in line with the other hole in the socket, and also with the tapped hole in the end of the "backbone," and through all three is inserted a 6-BA screw which, when tightened, securely clamps filter, socket and can together.

From the foregoing it will, perhaps, have been gathered that the filter is inserted in the screening can with the "backbone" support resting in one corner and the coil formers projecting diagonally across the can. In order to prevent any likelihood of the filter's wiring "earthing" to the inside of the can (except where intentional, i.e., at the input and output ends), the inside of the can should either be coated with a good insulating varnish or protected by a strip of thin insulating material.

There is an "earth" wire running alongside the "backbone" to which the "earthy" ends of capacitors C_1, C_2, C_3 and C_4 are joined and this is terminated at each end by soldering to one of the fixing lugs on the base of the coaxial sockets.

The output socket, which is located at the bottom when the filter is inserted in the can, is secured to

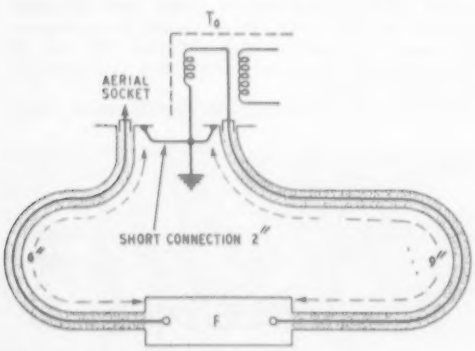


Fig. 5. Method of arranging connecting cables when the filter is fitted inside the convertor.

the "backbone" by a 6-BA screw. This screw holds in position also a short strip of brass, or aluminium, in which is drilled a 6-BA hole at each end. These holes are located so that when the socket is screwed to the "backbone" the hole at the free end of the strip coincides with the hole in the fixing lug of the screening can. The other hole in the coaxial socket's base should align with the other fixing lug on the screening can.

The coaxial sockets admittedly complicate the construction of the filter and in certain cases they could be omitted. The sockets are fitted mainly to enable the filter to be used as a separate unit external to any Band-III convertor and inserted in the aerial feeder if break-through of Band-I signals is affecting the Band-III picture. This must not be confused, however, with direct pick-up of signals on the convertor's wiring, as an external filter will obviously not cure this particular form of television interference.

If the filter is to be used solely, or at least initially, with the Simplified Band-III Convertor the two coaxial sockets can be omitted and replaced by the appropriate lengths of 75-ohm coaxial cable terminated at their free ends with coaxial plugs if so desired. The input cable has to be 6in long if a short rod aerial is employed, otherwise any convenient length can be used to join the filter to the aerial coaxial socket on the convertor. The output of the filter must always be connected to the input transformer (T$_6$ Fig. 2, page 134, March issue) by a 9-in length of coaxial cable. When the filter is housed inside the convertor these pieces of cable can be disposed of as shown in Fig. 5.

I.T.A. Midlands Relay

POST OFFICE RADIO LINK TO LICHFIELD TELEVISION STATION

WHEN a new television transmitting station such as Lichfield or the new I.T.A. Yorkshire station, scheduled for later in the year, is opened, it is the responsibility of the Post Office to transmit the vision and sound signals from the I.T.A. programme switching centre to the transmitter with no noticeable deterioration in quality and with a high standard of reliability.

A network of Post Office coaxial cable trunk circuits serves the Midland Area B.B.C. stations but such a network when fully loaded cannot readily be extended to carry additional programmes and it may then be of advantage to provide a radio system in one of the frequency bands recommended at the Atlantic City Convention for fixed point-to-point communication links.

The Post Office has successfully operated a radio-relay system using v.h.f. frequencies of about 200 Mc/s, but restrictions in frequency space due to the growing demand by other services for further allocations in this part of the spectrum, and the fact that broad-band signals are more readily accommodated at higher frequencies, have encouraged the use of centimetric waves.

No broad-band radio-relay system for television operating above 4,200 Mc/s has yet been put into service in the U.K. The Post Office television links to Kirk O' Shotts, Isle of Wight, Aberdeen, Norwich and Lichfield have used frequencies of the order of 2,000 Mc/s or 4,000 Mc/s, and these will also be used for further links for both B.B.C. and I.T.A. services and for broad-band multi-channel telephony links forming part of the trunk network.

Factors which are related directly or indirectly to the frequency of operation are the attenuation of the radio propagation path and its susceptibility to fading, the gain of aerials of a given size, the characteristics of aerial feeders, the available transmitter power and receiver noise factor. Future systems planned for the same route or area have also to be considered before deciding on the frequencies to be used on a specific link. However, despite the variety of factors involved and the widely differing techniques employed, both 2,000 Mc/s and 4,000 Mc/s systems have been developed to meet exacting requirements for performance and reliability laid down by the Post Office, and in general no clear advantage can be demonstrated by either over the other.

The Lichfield station, which lies about 12 miles to the north-east of Birmingham, is served by two television channels from Telephone House, Birmingham, to Lichfield and one return channel, on frequencies of 1,712 Mc/s, 1,784 Mc/s and 2,216 Mc/s respectively. Although the path length is comparatively short, it has been necessary, in order to obtain a radio path unobstructed by high buildings in the city, to erect the Birmingham aerial, an 8 ft diameter, spun-aluminium paraboloid reflector, about 30 ft above the roof of Telephone House and 133 ft above street level. At Lichfield a 12 ft diameter reflector is mounted at a height of about 140 ft from ground level on the I.T.A. station mast.

Aerial Characteristics

At 2,000 Mc/s the aerial gains relative to an isotropic radiator are approximately 31 and 34.5 dB and the beam width about 5° and 3° at the half-power points for 8 ft and 12 ft diameter aerials respectively. The three channels share a single aerial at each terminal. This is a very desirable feature in view of the possibility of the wind loading on a large paraboloid reflector reaching several tons in a gale. A rigid tower structure is necessary to prevent deflection of the relatively narrow radio beam, and additional aerials would complicate the problem and increase the cost of the towers which represent a substantial item in the total cost of the link. The r.f. multiplexing of three channels on each aerial is achieved by using horizontal and vertical polarization for the two directions of transmission and combining two channels on one type of polarization by means of an r.f. channel dropping, or combining, unit referred to later. The reflector is excited from a waveguide launching unit at the focus. This comprises a sec-

tion of waveguide short-circuited at one end and containing two probes mounted in space quadrature. Each probe is fed by a helical membrane feeder cable of 75 ohms characteristic impedance, pressurized with dry air. Two types of cable are available with attenuations of 1.75 dB or 2.6 dB/100 ft at 2,000 Mc/s.

Frequency modulation is adopted as it has the advantages over amplitude modulation of allowing the linearity requirements of the overall performance to be more easily met, and of a higher video signal-to-noise ratio. The latter arises from the characteristic "triangular" noise distribution associated with frequency modulation, i.e., a noise-power per unit bandwidth that increases with increase of video frequency at 6 dB/octave, a higher noise being tolerable in a television signal at higher video frequencies.

The peak-to-peak deviation employed is 7 Mc/s, and the bandwidth occupied by the transmitted signal at peak deviation about 14 Mc/s. Each transmitter and receiver comprises two racks of equipment of the type shown in Fig. 1.

At the transmitting terminal the incoming video signal, after amplification and d.c. restoration, is applied to a modulator which delivers a frequency modulated output signal at a mean frequency of 60 Mc/s and with full deviation.

An a.f.c. system associated with the modulator ensures that the frequency corresponding to the bottom of the synchronizing pulse is stabilized, and operates by the comparison of the modulator signal frequency during synchronizing pulses, with the cross-over frequency of a discriminator circuit. A bias is developed proportional to the difference between these frequencies and is applied to the modulator in a sense that tends to reduce the difference.

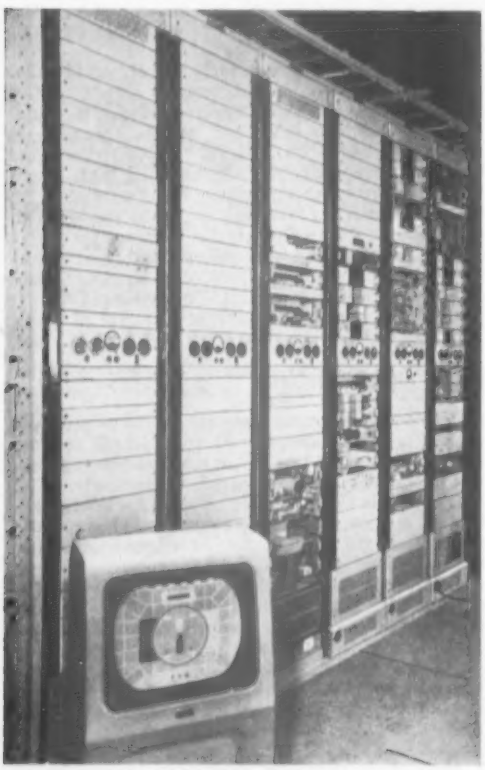


Fig. 1. Two terminal receivers and one transmitter at the Lichfield end of the Post Office 2,000-Mc/s radio link.

The modulated 60-Mc/s signal is amplified in several stages of wideband amplification and applied to a u.h.f. frequency changer. The u.h.f. stages comprise a frequency changer, an oscillator and three amplifiers; disc-seal triodes are used in each stage, designed to function as an integral part of two concentric line anode-grid and grid-cathode circuits each tuned to resonance at the appropriate number of quarter-wavelengths by non-contact bridges. Loops and adjustable probes coupled to these circuits provide means for injecting or extracting signals.

The frequency of the u.h.f. oscillator is stabilized within 60 kc/s by a reference cavity the resonance frequency of which is frequently modulated over ± 0.7 Mc/s at 50 c/s by a small metal disc rotated by a synchronous motor at 1,500 r.p.m. A crystal detector is coupled to the field within the cavity, the 100-c/s modulation component is filtered out and, if the cavity frequency differs from the oscillator frequency, a fundamental 50-c/s component is present which represents in amplitude and phase the extent and sense of the frequency difference; this component is selected and used to control an induction motor which mechanically resets the anode circuit tuning bridge.

The final amplifier stage comprises two u.h.f. 1-watt amplifiers operating in the circuit shown in Fig. 2. This circuit includes two coaxial line hybrid rings and the principle of their use as a ring mixer has been described in *Wireless World*, March, 1954, page 139. In this application of the circuit freedom from troublesome feeder and aerial echo effects is ensured and a better impedance match to the feeder is obtained than is practicable with a conventional output circuit. The hybrid rings are connected by two line sections of equal length in each of which is an amplifier. By mutual displacement of the amplifiers in the line sections and by tuning of their output circuits above and below the carrier frequency the outputs of the amplifiers provide a mismatch to the lines which present conjugate impedances at points 1 and 2. Echo or reflected signals returning at point 3 will divide in the arms of the ring and combine at point 4 to be dissipated in the resistive load. The amplifier output signals are in phase at the aerial feeder connection but in antiphase at the load. The final amplifier stage comprising the two disc-seal triode valves in coaxial line circuits and a coaxial line hybrid ring is shown in Fig. 3.

The hybrid ring circuit is also used as a channel combining or dropping filter, serving to multiplex r.f. channels on a common aerial, by substitution of appropriate band-stop filters for the amplifiers in the circuit shown.

A superheterodyne receiver is used comprising a silicon crystal frequency changer, u.h.f. local oscillator, low-noise pre-amplifier and main i.f. amplifier, limiters, a two-tuned-circuit or Round-Travis discriminator and video amplifier. By careful design of the input stages of the receiver a noise factor of 15 dB is achieved.

Under free-space propagation conditions there is a loss of about 124 dB in the Birmingham-Lichfield radio path, which is relatively short, the average being about 30 miles for u.h.f. and s.h.f. television links. However, the need for long aerial feeders at both terminals, for channel dropping filters and the use of a small aerial at one terminal result in a carrier level at the input to the receiver frequency changer of not more than 100 millimicrowatts, which is somewhat less than would be expected on a path of average length.

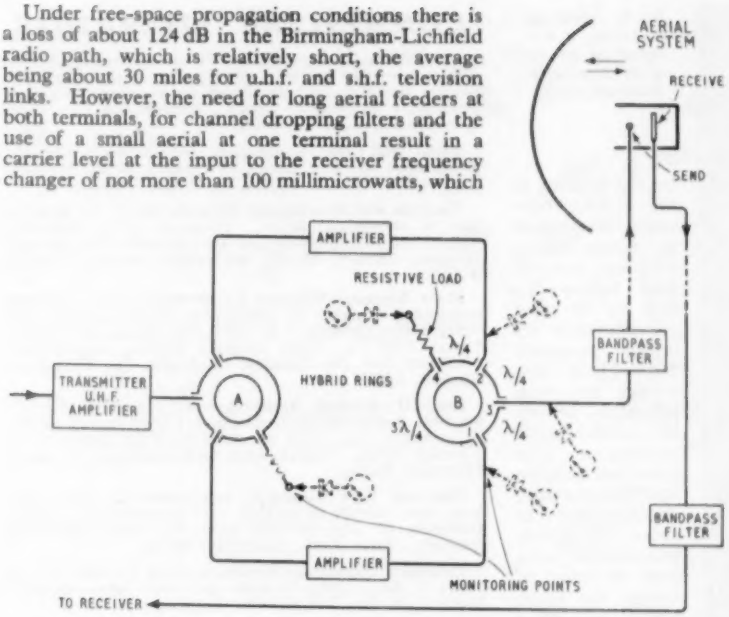


Fig. 2. Hybrid ring circuits are used in the final amplifier stage of the 2,000-Mc/s transmitter.

The pre-amplifier of the receiver comprises seven stages, of which the first two are low-noise earthed-grid triodes. The pre-amplifier and main i.f. amplifier are tuned as "staggered triples" in which one stage is tuned near the mid-band frequency and two other stages are tuned above and below this frequency. The bandwidth is 16 Mc/s at −3 dB points. Automatic-gain-control action on both amplifiers maintains the output level constant within 3 dB for variations from the normal input level of +10 dB to −20 dB. An adequate margin in overall signal-to-noise ratio allows for much deeper fading than is likely to be experienced on this link.

The specification for the radio equipment has to allow for the variety of design techniques offered by different manufacturers, and is therefore primarily a statement of a required overall transmission performance in terms of signal-to-noise ratio, attenuation-frequency, phase-frequency and linearity characteristics, waveform response at low frequencies, transient response to a step-waveform, stability of gain, etc. Ideal free-space propagation conditions are assumed and it is the responsibility of the Post Office to ensure that fading, site noise and reflections from obstacles such as buildings do not degrade the performance below an acceptable limit. The performance of a short path in these respects may be estimated sufficiently accurately from a map and site survey, but if long or difficult paths are involved the Post Office undertakes propagation tests on site on a long-term basis if necessary.

The testing of television links, either initially on completion or for routine purposes, can be a somewhat involved procedure and improvements in testing techniques are continually being sought and introduced. The trend is for the tedious investigation of steady-state responses to be largely replaced by a rapid check of a complex waveform designed to provide much of the information previously obtained.

In order to serve the Lichfield transmitter from London, as well as from Birmingham, an extension of the system to Birmingham Telephone House from the Post Office distribution centre for television circuits in the Museum Telephone Exchange Building in London is necessary. Here the main line or radio-link circuits to and from Birmingham and the North, Wenvoe, St. Margarets Bay and the Isle of Wight terminate in a television control room together with numerous short-tie studio circuits used to connect places of interest in the London area with the B.B.C. switching centre at Lime Grove, or with I.T.A. switching centres at Television House or Foley Street. The London-Birmingham link used is that which was originally brought into service in 1949

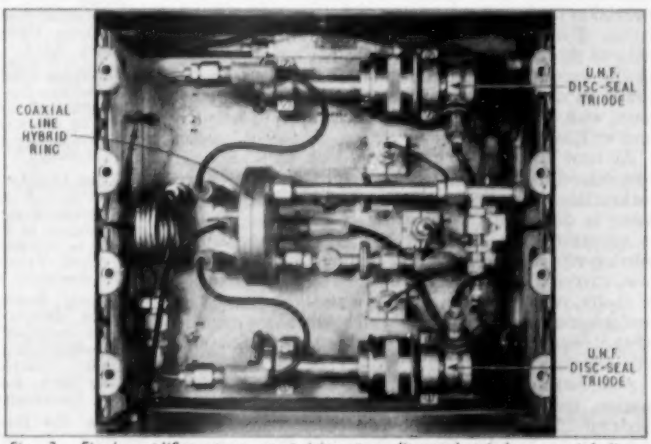


Fig. 3. Final amplifier stage comprising two disc-seal triodes, coaxial line circuits and hybrid ring.

Fig. 4. Tower supporting u.h.f. aerials on the roof of the Birmingham Telephone House.

for the opening of the B.B.C. television transmitter at Sutton Coldfield and was the first radio-relay link to be used for television relaying purposes. Since 1950 this service has been provided mainly by coaxial cable circuits. The radio link includes four intermediate stations and in order to obtain line-of-sight paths over 40 miles in length the route makes good use of natural land contours, and the intermediate repeater stations are situated on the Elstree ridge north of London, the Chiltern Hills, the Cotswold Hills and the high ground to the west of Birmingham. The link has recently been modified slightly in design in order to conform with current performance specifications but differs from later links in several important features; the radio equipment is housed in cabins at the top of towers, a practice that has not since been repeated; valves are operated in parallel in most stages, a safeguard which is no longer considered necessary; instead of a solid surface the paraboloidal reflectors are formed from parallel tubes spaced approximately one quarter-wavelength apart with provision for heating the tubes to prevent an accumulation of ice. In over six years' operational experience of this link, however, no case has been recorded of the necessity for aerial de-icing. Fig. 4 shows the tower on the roof of the Telephone House, Birmingham, with aerials for the u.h.f. radio links to London and to Lichfield.

As new techniques are introduced so additional specialized training has to be given to the Post Office technicians who maintain the links. The equipment is designed for unattended operation, but it is necessarily so complex that only by the unremitting efforts of an efficient maintenance organization, carrying out frequent routine tests and analyses of faults, is it possible to achieve those standards of performance and reliability which are characteristic of the television relaying network now operating in this country.

Acknowledgment and thanks for some of the information contained in this article are due to the General Electric Co., Ltd., who manufactured and installed the London-Birmingham and Birmingham-Lichfield radio-relay links.

COMMERCIAL LITERATURE

Silver Rivets for contacts; new low-cost design using silver facing on copper backing, with tubular shanks to simplify riveting operation and avoid stresses on contact supports. Descriptive leaflet from Johnson, Matthey and Co., 73-83, Hatton Garden, London, E.C.1.

Aerial Wall Chart, giving quick reference (with diagrams) to television and v.h.f. aerials for Bands I, II and III made by Aerialite, of Castle Works, Stalybridge, Cheshire.

Tungsten and Molybdenum Wires for use in the manufacture of valves and lamps. Catalogue giving diameters, weights and other physical data from Mullard, Raw Materials Division, Century House, Shaftesbury Avenue, London, W.C.2.

Phase Sequence Indicator for showing correct or incorrect phase sequence in 3-phase a.c. mains supplies with voltages varying from 5 to 500V and frequencies between 5 and 1500 c/s. Uses rectifiers working back-to-back. Literature from the Electrical Instrument Co. (Hillington), Glasgow, S.W.2.

Band-III Stacked Aerial Arrays, composite Band-I/Band-III aerials (indoor and outdoor types), and an adaptor kit to enable f.m. sound transmissions to be picked up on television aerials. Leaflets from Antiference, Bicester Road, Aylesbury, Bucks.

Disc and Tape Recorders, direct-recording discs, magnetic tape, amplifiers, pickups and cutter-heads. Leaflets describing all their products from the M.S.S. Recording Company, Poyle Farm, Colnbrook, Bucks.

Television Distribution System, covering 13 channels, for blocks of flats, hotels, hospitals and other large buildings. Leaflet from Pye, P.O. Box 49, Cambridge.

Digital Frequency Meter, covering 10 c/s to 30 Mc/s, working on a gating and counting principle with crystal-controlled time intervals. Megacycles are read on a calibrated dial and kc/s and c/s on a digital indicator with 6 decades (up to 999,999 c/s). The accuracy is ±1 count. Descriptive leaflet from Racal Engineering, Western Road, Bracknell, Berks.

Echo Sounder Simulator is now available for training fishermen to operate the Kelvin Hughes "Kingfisher" echo sounder. Leaflet describing the "Kingfisher" itself (using electrolytic recorder and c.r.t. viewing unit) from Kelvin and Hughes (Marine), 99 Fenchurch Street, London, E.C.3.

Nickel Alloys, as used in valves for r.f. heating, in strip-wound cores for inductors and transformers, and in long-life valves for submarine repeaters. Well-written articles in "Wiggin Nickel Alloys," No. 39, from Henry Wiggin and Company, Wiggin Street, Birmingham, 16.

Components and Accessories; a May, 1956, illustrated catalogue from Radiospares, 4-8, Maple Street, London, W.1.

Solder Wires, solid and resin-cored; solder paints, liquid fluxes, solder preforms and other products listed in a catalogue from Enthoven Solders, 89, Upper Thames Street, London, E.C.4.

Television Distribution System covering channels 6 to 13 with facilities for introducing f.m. signal. Uses cascode pre-amplifiers with cathode-follower output units giving outputs for 6, 36 or more receivers as required. Leaflet from the Rainbow Radio Manufacturing Co., Mincing Lane, Blackburn, Lancs.

Signal Generator, small servicing type, covering 150 kc/s to 220 Mc/s in six bands, with a continuously variable output attenuator and four-step decade multiplier giving maximum signals of 100 μV, 1 mV, 10 mV and 100 mV. Leaflet from The Automatic Coil Winder and Electrical Equipment Co., 92-96, Vauxhall Bridge Road, London, S.W.1. Also a leaflet describing a new range of tropicalized Avometers.

Silicone Rubber, notable for maintaining dielectric strength, dielectric constant and power factor throughout a wide temperature range (−50°C to 150°C); also for maintaining surface resistivity under conditions of high humidity. Electrical and other properties described in a booklet from the Dunlop Rubber Company, Cambridge Street, Manchester, 1.

Silica Gel Dessicant for protecting equipment against moisture. An illustrated brochure on methods of humidity protection and the applications of "Sorbsil" Silica Gel made by Joseph Crosfield and Sons, Warrington, Lancs.

"Why didn't I think of them before! Everybody knows FURZEHILL make the best VALVE VOLTMETER in the world . . . Come to think of it, their stuff has never let me down. In fact, my motto is the same as theirs: Furzehill for today and tomorrow."

Furzehill Laboratories Ltd.

CLARENDON ROAD, WATFORD, HERTS.

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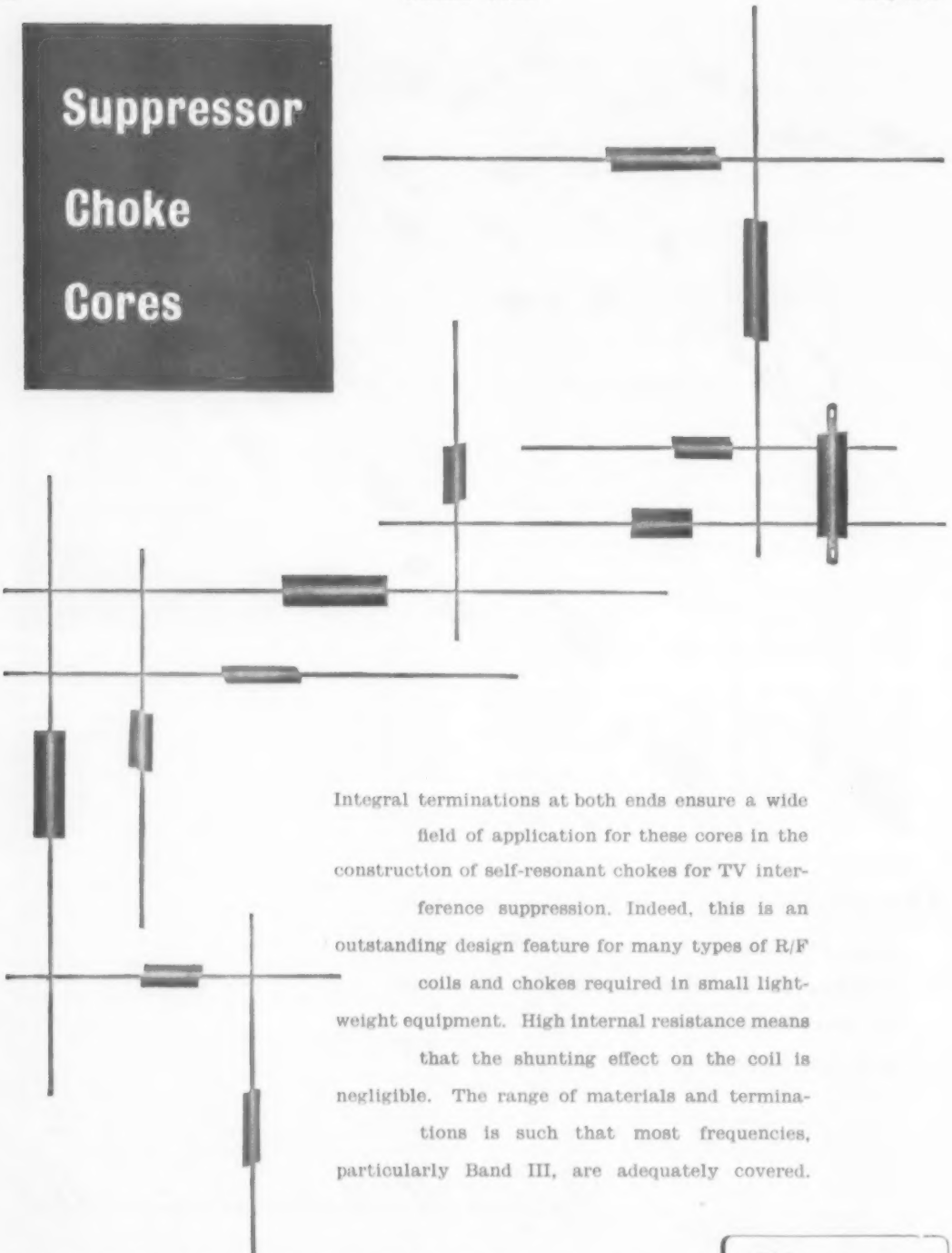
F

Suppressor Choke Cores



Integral terminations at both ends ensure a wide field of application for these cores in the construction of self-resonant chokes for TV interference suppression. Indeed, this is an outstanding design feature for many types of R/F coils and chokes required in small lightweight equipment. High internal resistance means that the shunting effect on the coil is negligible. The range of materials and terminations is such that most frequencies, particularly Band III, are adequately covered.

Literature and sample cores are readily available to Design Engineers on request.

Plessey

THE PLESSEY COMPANY LIMITED, CHEMICAL & METALLURGICAL DIVISION, WOOD BURCOTE WAY, TOWCESTER, NORTHANTS. TEL: TOWCESTER 312

P.C.7

Television Receiver Input Impedance

By J. E. HOPKINS,* B.Sc.

Formulæ for Use in Conjunction with Bridge Measurements

MEASUREMENTS of the input impedance of television receivers (on Band I) are usually made using an admittance bridge. When making these measurements it is convenient to connect the input terminals of the receiver to the bridge terminals by coaxial cable. Given below is an analysis of the measurements to be made and the application of well-known formulae to the problem. Three measurements only are required and from these the required input impedance can be calculated.

If the length of the connecting cable is small we can assume that the attenuation is negligible. For such a length of cable of characteristic impedance Z_0 and electrical length θ radians, terminated by an impedance Z_x, the input impedance Z_{in} is given by:—

$$Z_{in} = r_{in} + jx_{in} = Z_0 \frac{Z_x + Z_0 j \tan\theta}{Z_0 + Z_x j \tan\theta} \quad .. \quad (1)$$

For a short circuited line $Z_x = 0$ and equation (1) becomes:

$$Z_{sc} = Z_0 j \tan\theta \quad .. \quad .. \quad .. \quad .. \quad (2)$$

For an open-circuited line $Z_x = \infty$ and we may therefore write

$$Z_{oc} = \frac{Z_0}{j \tan\theta} \quad .. \quad .. \quad .. \quad (3)$$

Substituting equations (2) and (3) in equation (1) we have:

$$Z_{in} = \frac{Z_x + Z_{sc}}{1 + \frac{Z_x}{Z_{oc}}} \quad .. \quad .. \quad .. \quad (4)$$

Rearranging equation (4) we obtain a formula for Z_x in terms of Z_{oc}, Z_{sc} and Z_{in}, that is:

$$Z_x = \frac{Z_{in} - Z_{sc}}{1 - \frac{Z_{in}}{Z_{oc}}} \quad .. \quad .. \quad .. \quad (5)$$

We can now outline the three measurements to be made: (a) a measurement of the impedance of the cable open-circuited (Z_{oc}); now as the cable length is so small the resistive component is negligible compared with the reactive component, i.e., $Z_{oc} = j\,x_{oc}$; (b) a measurement of the impedance of the cable short-circuited (Z_{sc}); again the resistive component may be ignored and $Z_{sc} = j\,x_{sc}$; (c) a measurement with the unknown impedance connected to the cable ($Z_{in} = r_{in} + j\,x_{in}$). We can now write equation (5) in a more convenient form thus:

$$Z_x = r_x + j\,x_x = \frac{r_{in}\,x_{oc}\,(x_{oc} - x_{sc})}{r_{in}^2 + (x_{oc} - x_{in})^2} + j\,\frac{x_{oc}\,x_{in}(x_{oc} + x_{sc}) - x_{sc}x_{oc}^2 - x_{oc}(r_{in}^2 + x_{in}^2)}{r_{in}^2 + (x_{oc} - x_{in})^2} \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (6)$$

Results from the admittance bridge give Z_{in} in the form of an admittance (G) in parallel with a capacitance (C). This must be converted to a series form in order to use equation (6), i.e., a resistance $r\left(=\frac{G}{G^2 + \omega^2 C^2}\right)$ and a reactance $x\left(=\frac{\omega C}{G^2 + \omega^2 C^2}\right)$

It it is necessary to convert from the series form to the parallel form then

$$R_p = \frac{r_s^2 + x_s^2}{r_s} \text{ and } x_p = \frac{r_s^2 + x_s^2}{x_s}$$

When using equation (6) it is essential that for measurements (a) and (b) the resistive component may be ignored when compared to the reactive component; to this end the cable used is made very short or, more suitably, cut to a length of approximately half a wavelength.

Incidentally multiplying equation (2) by equation (3), we obtain:

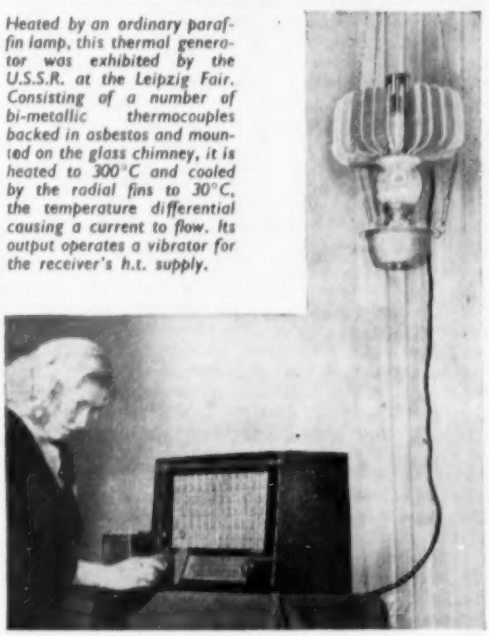
$$Z_{sc} \cdot Z_{oc} + Z_0^2 \quad .. \quad .. \quad .. \quad .. \quad (7)$$

giving $Z_0 = \sqrt{Z_{sc} \cdot Z_{oc}} \quad .. \quad .. \quad .. \quad (8)$

Thus we have a useful method of finding the characteristic impedance, Z_0, of a length of cable.

* Ferguson Radio Corporation

THERMO-ELECTRIC RECEIVER



Heated by an ordinary paraffin lamp, this thermal generator was exhibited by the U.S.S.R. at the Leipzig Fair. Consisting of a number of bi-metallic thermocouples backed in asbestos and mounted on the glass chimney, it is heated to 300°C and cooled by the radial fins to 30°C, the temperature differential causing a current to flow. Its output operates a vibrator for the receiver's h.t. supply.

Monitoring Sound Broadcast

EVOLUTION OF PRESENT METHODS OF ASSESSING QUALITY

By T. SOMERVILLE,* B.Sc., M.I.E.E., F.Inst.P.

To ensure a satisfactory service to the listeners, broadcasting organizations have to monitor carefully all programme material. This monitoring, of course, extends not only to the technical standards of a broadcast but also to its programme content. In this article, however, discussion will be restricted to the technical standards of the audio-frequency signal leaving the studios. The reasons for monitoring are to detect technical faults and to allow the "balance" of the programme to be adjusted. Defects of a technical nature should obviously be removed, and for this purpose a broadcasting organization must be able to detect any faults which are likely to trouble listeners. "Balancing" an orchestra implies the placing of the microphone with respect to the performers to give the best balance between the various instruments as well as the best tonal quality. The question of balance is therefore more subject to controversy. It is necessarily largely a matter of opinion and personal preference, but is also influenced by the types of loudspeaker and microphone used and by the acoustics of the studio. This will be discussed later.

In establishing technical standards it must not be forgotten that the acoustic environment of the listener should be borne in mind, whether he is a listener at home or one of the monitors in the broadcasting organization. It is often argued that the standard used for monitoring should be that of the "average" listener and that it is unfair to employ standards to satisfy listeners who have provided themselves with better equipment and listening conditions. In practice this is not so. Most receiver manufacturers when testing a new design will endeavour to obtain the best results from the programme material being radiated by the B.B.C. There is therefore a desirable incentive to raise the general standards of technical quality if the B.B.C. maintains its standards at a level higher than that of the majority of current receiving equipment.

In the early days of broadcasting most of the studio and transmitting apparatus was experimental and it was some time before properly engineered equipment began to come into service. The listeners' equipment was even more rudimentary than that used in the studio and remained so for some time. Progress in the development of broadcasting equipment was steady, so that by 1930 a high standard of studio and transmitting apparatus had been reached. The development of receivers was more gradual but, even so, by 1939 a reasonable standard had been obtained, although only the most expensive receiving equipment could match the standards of the transmitting equipment. Hitherto it is mainly in loudspeaker design that progress has been lacking, so that even expensive receivers of what is called the "high-fidelity" type often have inferior loudspeakers. Since the war there have been gratifying developments in the loudspeaker field, but the standard of home equipment still lags behind the studio apparatus.

Not all the developments in audio-frequency systems can be attributed to the influence of broadcasting. The gramophone industry has done much in recent years to stimulate the development of better equipment by the production of disc and tape recordings having a wide frequency range.

Although the major developments in high-quality receiving apparatus have taken place since 1945, it was possible before 1939 to obtain loudspeakers which covered a wide range of frequencies. None of these was used for monitoring by the B.B.C. but, nevertheless, B.B.C. loudspeakers were better than those in the average commercial receiver. It should be realized that in B.B.C. practice every programme is monitored, first at the originating studio and subsequently at other points in the system before it is radiated from the transmitters. For this purpose it is necessary to have suitable loudspeakers and a suitable acoustic environment in which to listen to them. This environment should approximate to the acoustic conditions of a living room, and more will be said on this subject later. The loudspeaker should be good enough to enable the monitor to hear faults which might give trouble to listeners with good equipment, and if this requirement is satisfied there will be few justifiable complaints from the majority of listeners with ordinary commercial receivers. Soon after 1945 it became clear that many wide-range loudspeakers were becoming available and it therefore became necessary to select better monitoring loudspeakers for use throughout the broadcasting organization.

Loudspeakers.—The selection of a loudspeaker introduces quite unexpected difficulties. If several commercial loudspeakers are listened to on normal programme material it will often be found that the loudspeaker preferred depends on the programme material. This was found in the early tests on the subjective selection of wide-range loudspeakers. Such a situation is extremely unsatisfactory, since clearly it is not possible to use different loudspeakers for different types of programme. In an endeavour to find the cause of this anomaly, the loudspeakers were taken to a studio to enable a comparison to be made with the original programme. The studio was an orchestral studio. Here again the results were anomalous, because it was then observed that the loudspeaker preference depended upon the type of music being performed. At this stage it was noticed, while listening in the studio, that the orchestra itself sounded confused so that it was difficult to hear all the instruments.

* Research Department, B.B.C.

† Complete diffusion implies uniform distribution of sound energy throughout an enclosure.

Programmes

As the acoustics of the studio were known to be poor it was considered that this fact might explain the anomalies.

Studio Acoustics.—Perhaps at this point it might be of interest to describe the way in which the acoustics of a studio can be assessed subjectively, merely by listening in the studio during a rehearsal. Although this may seem to be an over-simplification, it is a feat easily accomplished by a skilled listener without the aid of measuring equipment. With experience it is possible to assess the mean reverberation time approximately, to decide whether a studio is too reverberant or under-reverberant, and the frequencies at which colorations or other acoustic effects are noticeable. Diffusion† can be judged by moving about while listening with one ear. When diffusion is good the sound is distributed uniformly throughout the auditorium and there is little change in the ability to hear all the parts in an orchestral performance. Incidentally, this also means that the microphone position will not be critical. Listening with one ear only, it should also be possible to hear all the instruments even in very loud passages. If diffusion is poor and consequently the sound is not distributed uniformly, troublesome standing waves exist. Microphone positioning is therefore difficult and for the audience the interference patterns which accompany standing waves make the hearing of all parts in the music impossible. In addition poor diffusion results in sound dying away in an irregular fashion, thereby producing the subjective effect of hard tonal quality. Diffusion is normally achieved by having irregular surfaces on the walls and ceiling, which in the older concert halls took the form of baroque ornamentation or coffering. Fig. 1 shows the B.B.C. orchestral studio at Maida Vale in which can be seen the modern form of rectangular diffusing elements on walls and ceiling. If there are any large areas of panelling which resonate at a particular frequency this frequency will often be heard after the wanted sound has died away and the subjective result is called "coloration." The same method of selection applies to all studios, even talks studios, with the difference that it may be necessary to listen to the decay of tone to assess the acoustic performance, as music is not played in such studios.

Selection of Loudspeakers.—To check whether poor acoustics could indeed cause the difficulties experienced in selecting loudspeakers, the whole experiment was transferred to a good orchestral studio, where the consistent selection of loudspeakers was shown to be possible. Furthermore, it was found that the majority of commercial loudspeakers failed to give reasonable reproduction of the symphony orchestra used for the test; only three gave a satisfactory performance. Let us call these speakers A, B and C. At this juncture it was realized that, in making the selection tests, the balance had been carried out using a loudspeaker which was of type B. As this operation has to be accomplished by listening to a loudspeaker it is obvious that the type of loudspeaker may affect the result. The loudspeaker in the monitoring cubicle was therefore changed to type A to determine the effect of

Fig. 1. B.B.C.'s main orchestral studio at Maida Vale, showing rectangular diffusing elements on walls and ceiling.

Fig. 2. Listening room in the B.B.C. Research Department. It has a reverberation time of 0.4 sec.

the characteristics of the loudspeaker used for balancing, on the microphone position adopted. In re-balancing, the studio manager then moved the microphone to a more distant and higher position which gave extremely satisfactory results on loudspeakers A and C, increasing the perspective and sense of realism, and caused B to be rejected. It is interesting to note that loudspeakers A and B were single-cone units made by a well-known British manufacturer, and loudspeaker C was a wide-range American unit. It is also worthy of note that this was the first occasion on which satisfactory reproduction had been obtained on a wide-range loudspeaker; previously the results had always been hard, shrill and unpleasant. To complete the experiment, loudspeaker C was then used for monitoring, resulting in only a very slight change in microphone position from that found with loudspeaker A and still giving satisfactory results on both A and C but not on B.

In addition to tests such as that just described, it is obviously necessary to make tests on other programme material including speech. A speech test is one of the most exacting to which a loudspeaker can be subjected, since the human voice covers a very wide range of frequencies. If the speaker is known to the listeners, a very stringent test is possible. The speaker should be placed in a non-reverberant room or should speak out-of-doors to eliminate acoustic effects. Such a test is found to eliminate the majority of commercial loudspeakers.

Another factor in the subjective selection of loudspeakers which remains to be mentioned is the effect of the type of microphone employed for the tests. Fortunately microphone design has reached a stage at which most broadcasting microphones are much better in performance than any loudspeaker, so that for this type of loudspeaker test the effects of the microphone are not important.

Resulting from the early experiments, a technique for the subjective selection of loudspeakers has been evolved. Measurements and listening tests eliminate all the worst examples, so that the final test need be applied only to those loudspeakers having a reasonable measured performance. The loudspeakers are placed behind a gauze curtain which is illuminated in front to prevent the panel of subjects from seeing the loudspeakers. The subjects are asked to say which unit gives the best reproduction of the original sound. In the case of speech, the speaker actually talks behind the screen as well as talking in a non-reverberant room with a microphone. For music, the tests are done at a studio centre where the subjects are at liberty to listen in the studio before giving their opinions.

The final test, carried out in music studios only, with the loudspeakers concealed behind the screen, is to ask studio managers to balance the orchestra in turn with each of the loudspeakers under test, and to observe the resulting microphone positions. Loudspeakers with abnormalities will often cause the microphone position to be far removed from normal, while with very bad loudspeakers it is sometimes impossible to obtain a balance, using only one microphone. Although it is common practice to use more than one microphone to obtain special effects, particularly in variety and dance music, the introduction of so many variables into a loudspeaker test makes a valid comparison almost impossible. With many of the loudspeakers in commercial receivers, multi-microphone techniques would be necessary to achieve a good balance, and this balance would then be acceptable only if all listeners used loudspeakers with the same characteristics.

The tests described facilitate the introduction of improved loudspeakers which can be used for monitoring in the certain knowledge that the results will still be acceptable on older loudspeakers having a more restricted frequency range. This is an essential requirement because it is obviously uneconomic to replace all the loudspeakers in a large broadcasting organization at any given time. A progressive programme of replacement with continually improved loudspeakers is the only economic solution.

Microphones.—Similar methods of selection are applied to microphones. As loudspeakers improve it is possible to carry out experiments leading to better microphones and then return again to loudspeakers. Thus by improving successive parts of the chain it has been possible to raise the standards of broadcasting to a marked degree during the last ten years.

Listeners' Acoustic Environment.—It was mentioned earlier that a suitable environment is essential for the monitoring of broadcast programmes. In the B.B.C. the first approximation to this was to

adjust listening rooms to have a reverberation time of 0.5 sec, a figure established by the Building Research Station as the average figure for a large selection of normal living rooms. For a number of years this reverberation time proved to be satisfactory; there is no doubt that for musical programmes the value is still suitable. Unfortunately, in the development of talks studios it became necessary to reduce the reverberation time to the region of 0.3 sec to remove colorations. It was then observed that faults in the acoustics of such talks studios could not be detected with any certainty in listening rooms with reverberation times of the order of 0.5 sec. This indicated the need for the reduction of the reverberation time of listening rooms, but before considering any changes a survey of living rooms was carried out. Measurements were made in a selection of living rooms, supplemented by listening tests consisting of the reproduction on a wide-range loudspeaker of a recording of well-known announcers speaking from a number of B.B.C. studios. Careful observations were made of the living room conditions under which it was possible to hear differences in studio acoustics. It was established that reverberation times in excess of 0.4 sec obscured the effects which monitors should hear in talks studios.

As a result of this investigation it is now B.B.C. practice to adjust its listening rooms to have a reverberation time of 0.4 sec. Fig. 2 is a photograph of the listening room in the B.B.C. Research Depart-.nent which now has a reverberation time of 0.4 sec. Two loudspeakers are being compared. A further interesting conclusion from the tests was that the value of 0.4 sec often applies to well-furnished living rooms owned by listeners who can afford the better class of receiving equipment. It was also concluded that to reduce the reverberation time of listening rooms below 0.4 sec would be unrealistic because very few living rooms have values lower than this.

It is important to realize that it is only in the case of talks that the living room acoustics are important. For most other types of programme, reverberation times in the studios are much longer than 0.4 sec, and it is the studio reverberation which the listener hears—unless he listens in the bathroom.

Conclusions.—This survey of the methods of controlling broadcast quality shows that for studio monitoring it is not desirable to duplicate the conditions of the average home apart from the adjustment of the reverberation time of the listening room. The equipment used is at least as good as that employed by the most critical listeners. This policy has proved to be a wise one because, with the advent of frequency modulation and the great improvement possible in transmission and reception conditions, it is comparatively easy to provide satisfactory programme material without much change in broadcasting equipment. The position would have been very different if the policy had been to degrade standards to those of the "average" listener, even if it were possible to discover by statistical methods the type of equipment and listening environment employed by this hypothetical individual.

Colour Television in the United States

SIR HAROLD BISHOP'S VIEWS

THE director of technical services of the B.B.C., Sir Harold Bishop, spoke about colour television in the United States at a luncheon of the Radio Industries Club in London on April 24. Sir Harold had just returned from a visit to the United States.

He said that colour television had made a good start there but he thought progress would be slow until the price of sets dropped. The system which they had adopted—the N.T.S.C.—was capable of excellent results and intensive work on the development of television sets was continuing.

So far only about 25,000 colour television sets had been sold at a price of about 800 dollars (about £300) each. The service on these sets averaged about 100 dollars (£35) a year. The R.C.A. company was now making about 30,000 sets a month at a price of 700 dollars each. Sir Harold had been told that as manufacture developed it was hoped that the price would come down to about double the cost of an ordinary black-and-white television set.

Of the three big networks in the United States N.B.C. was radiating about 40 hours of colour television a month which was to be increased to 80 hours at the end of the year. C.B.S. was doing about 10 hours of colour television monthly and had recently reduced the hours. The other network—A.B.C.—was doing no colour transmissions.

Sir Harold Bishop referred to the cost of the programmes known as "spectaculars." They ran up to about a quarter of a million dollars (£90,000) for a half-hour programme.

About the prospects of colour television in Britain Sir Harold Bishop said that the B.B.C. had an open mind on what system should be adopted. It was the responsibility of the Television Advisory Committee —on which the Post Office, the industry and the B.B.C. were represented—to recommend the most suitable system. The B.B.C. had been accused in some quarters of spending public money in pushing a compatible colour television system on 405 lines. This was a misrepresentation of the facts. The B.B.C. was exploring all aspects of colour television for the information of the T.A.C., and its experiments would cover all bands and standards other than 405 lines in co-operation with the industry. It would be a long time before a decision was reached.

We regret that publication of *Wireless World* has again been delayed. Subsequent issues will appear at intervals of less than a month until the normal time of publication is resumed.

Reliability in Equipment

WHAT DOES IT DEPEND ON?

By ERNEST G. ROWE,* M.Sc., D.I.C., B.Sc.(Hons.), A.C.G.I., M.I.E.E.

EVERYONE in the electronics industry is vitally concerned with the need to achieve equipment reliability. No matter what specific field is involved, the demand is essentially the same—that the equipment marketed shall give the user trouble-free performance. Naturally the effort required to achieve this objective differs with the purpose of the equipment. At one end of the scale is the submarine repeater, where extreme precautions are taken because any failure will be inordinately expensive and at least 20 years' continuous operation is an economic requirement. At the other end of the scale is the sound and television broadcast receiver market, where it is nevertheless equally important to keep the set-owner satisfied.

In order to realize even a modest reliability in the overall equipment it must be appreciated that extremely high individual component reliability is necessary (see Fig. 1). During the last decade this problem has been very much in the forefront and has resulted in intense activity on the part of component makers and, in particular, the valve manufacturers, whose products have been demonstrated as giving more trouble than the others.

Hundreds of thousands of pounds have been spent in analysing the causes of valve failures, in establishing new valve designs which are free from such faults as were causing failures, and in the introduction of new manufacturing processes to produce valves in the higher category of reliability. While much of this work has been aimed primarily at producing valves to work under arduous vibrational conditions, it has been possible to utilize some of the knowledge so gained and to apply it to the mass of valves used in domestic sound and television. That the set designer knows this and has taken advantage of it is evident, because there are many cases where valves manufactured less than two years ago would no longer be acceptable in modern circuits.

The valve maker can now justly claim than when Special Quality valves are *used correctly*, the following problems may be regarded as solved: (1) Catastrophic failures which have been the cause of sudden equipment breakdowns. (2) Heater failures resulting from repeated switchings. (3) Microphonics and noise, particularly when associated with vibrational conditions. (4) Early life failures due to loss of emission and rise of "gas." It has also been established that the failure rates on such valves remain uniformly low up to some thousands of hours of operation.

What does all this mean in actual figures?

Well, the ordinary domestic valve for sound and vision sets has about 3% failures per year in the first year of operation. The same valves when used under vibrational conditions have shown average failure rates of the order of 20% in the first thousand hours of running.

However, the Special Quality valves designed to meet such arduous working give a corresponding figure of 1.5%.

To get better results than this is becoming increasingly difficult because the law of diminishing returns is beginning to operate and it is only by ignoring expense completely, and taking extreme precautions as well, that a figure better than 0.1% is possible.

What, then, is necessary if we are to get the higher orders of equipment reliability that are required for the future? As far as valves are concerned, if we take ideal equipment reliability as a figure of 100%, it is now apparent that even the perfect valve can only contribute 30% to that objective. The other 70% is the responsibility of the valve user, with 50% being dependent on successful equipment design, *operating the valve correctly and conservatively*, and 20% on the provision of satisfactory maintenance techniques.

Field Analyses.—There have been many large-

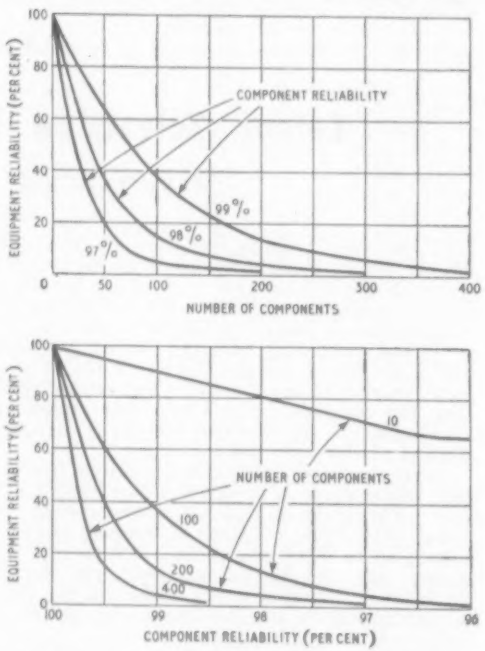


Fig. 1. Typical equipment-reliability component-reliability relationships. With 100 components of average reliability 99%, the equipment reliability is only 40%, i.e. 2 out of 3 equipments would fail during a specified period. Increasing the components to 400 with the same average reliability means that 98 out of 100 equipments would fail in the same period.

* Standard Telephones and Cables.

scale investigations under controlled conditions on large numbers of particular equipments but the following extracts are typical of the latest findings:

(i) In an equipment using ordinary domestic valves under arduous conditions the reasons for the failures of the valves in the various positions were as follows:

Position 1. Incompatibility between equipment design and valve specification.

Position 2. Excessive current surges in rectifier when switching-on due to the omission of the specified minimum series impedances.

Position 3. Faulty maintenance instructions.

Position 4. Critical for microphony and parasitic oscillations.

Position 5. Excessive anode dissipation.

Position 6. Heavy glass breakage due to removal difficulties in servicing.

Position 7. Bad valve design; mechanically weak.

Position 8. Use of wrong valve type, resulting in microphony.

Position 9. Excessive interelectrode leakage due to overrunning of the valve heater.

Position 10. Operation at too high a bulb temperature.

Position 11. Critical for noise and microphony.

(ii) In an equipment using Special Quality valves under arduous conditions, the reasons for the failures of the valves in the various positions were as follows:

Position 1. Operated above maximum ratings.

Position 2. Incompatibility of valve and circuit.

Position 3. Incompatibility of valve and circuit.

Position 4. High bulb temperatures causing bulb cracking.

Position 5. Weak performance; faulty circuit constants.

Position 6. Incompatibility of valve and circuit.

Such analyses as these demonstrate the many cases of trouble diagnosed as wrong valve usage, and that with Special Quality valves the whole onus of reliability will be thrown on the user. The valve is the most ubiquitous of all the components in an electronic equipment and it is subject to the most abuse. No equipment designer would think of using resistors or capacitors without allowing 100 or 200% safety factor on the published ratings but that same designer expects to be able to use valves at their published data or above without anticipating trouble because of this approach.

Design of Equipment.—Reliable electronic equipment design depends on: (a) the use of the most reliable components, of which valves are one; (b) the use of simple circuits wherever possible, with suitable derating of valves and components; (c) the use of new constructional techniques; (d) thorough testing under the conditions of use (this includes temperature and humidity cycling and vibration and shock testing); (e) the realization of the problems of the equipment user.

This brings to mind the concept of the "black box" or sub-unit with built-in methods of marginal checking and fault location. Methods such as these must be employed to supersede the arbitrary ones which start by the service technician removing the valves as his first action in fault diagnosis.

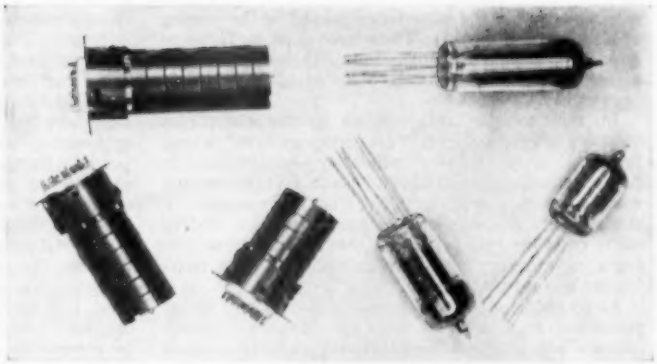


Fig. 2. Typical wired-in valves. Those to the right are normally placed horizontally on the chassis and held down with metal clamps. The left-hand three are supplied to the equipment manufacturer complete in sockets and with heat dissipating shields.

Such procedures must apply to all maintenance and servicing technicians. A typical example is in the ground servicing of aircraft. Valves have to be worked within a certain range of voltages and great care is taken on aircraft to ensure this. Yet it often happens that a ground service truck has manually operated or inadequately stabilized power supplies, as a result of which all the valves are subjected to excessive voltages.

It cannot be too strongly emphasized how important it is that valves should be used correctly. The valve is inherently a fuse and thus takes the blame for failures of equipment whether it is misused or has failed because of other component troubles or faulty servicing.

Because it is the valve that so often takes the blame, valvemakers' application laboratories have built up a concentration of knowledge gained by bitter experience. This information is freely available to all users of valves and, in addition, much of it has been gathered together in a document which explains the reasons for many of the desired precautions. This publication, known as the British Standards Institution Code of Practice CP1005 and entitled "The Use of Electronic Valves," should be in daily use by all circuit designers.

Similar documents have had restricted issue in the United States, but they all tell the same story, that careful attention to established rules, together with the closest collaboration with the valvemaker to ensure that he has adequately life-tested valves for use under specified conditions and has incorporated such conditions into his manufacturing test specifications, will result in greatly improved equipment reliability. There is increasing evidence that the Americans are taking more positive action than we are to ensure compatibility of components in equipment. They have elaborate and efficient field surveillance of failures whereby equipment and valve faults are classified. If valve manufacturers find equipment rejections of valves passing their specifications, they can ask for an independent investigation of the equipment to the mutual benefit of both customer and supplier, and there are plans for the widespread

dissemination of the experience gained by the issuing of suitable handbooks. They have gone so far as to have task teams of applications engineers who co-operate with the government services on any required project.

In this country many firms in the electronics industry are introducing "reliability groups" whose function is to supply reliability information to designers and manufacturers. Such groups conduct studies on current designs so that the mistakes of the past are not repeated in future designs, and in many cases are responsible for investigating new concepts, new designs, changes in manufacturing techniques and advanced technology.

As so much of the work carried out is now being published it should be easy for future university courses for graduate engineers to include lectures on the reliability concept, and for lecturers to explain statistical and probability theories as essential tools for the electronics engineer to use in parallel with his basic theory.

If these approaches are effective, and they must be if the electronics industry is to achieve reliability, what are the future plans of the valve-makers? From the production point of view it is possible for the techniques of "automation" to be exploited, not only to meet competition, reduce costs and overcome shortages of skilled labour, but also to contribute to the achievement of higher orders of reliability. Such techniques when applied to valves require more standardization and reduction of types, and, in some cases, new concepts in design from the outset.

The valve research engineer has realized that, having eliminated catastrophic failures, the major cause of valve failures is now the simple deterioration of valve characteristics. Five years ago, civil aviation would have been content with 1,000 hours reliable operation, but now it is usual for operating companies to fly 4,000 hours a year and so trouble-free performance is required for many thousands of hours.

As a result a great deal of research is being done in basic design, newer and better materials, new processing techniques and machinery to produce valves having consistent lives of the order of 20,000 hours or more. This work will take time, but the prospects are very good that valves, when used properly, can be fitted and forgotten.

Co-operation between valve-makers and equipment designers has already produced many exciting new approaches—unit system of construction, printed and potted circuits, mechanical jointing and other methods of avoiding dry joints.

It is not too early, either, for valves to become wired-in components (see Fig. 2). Already it has been established that the mechanical incompatibility between the pinned valve and the valveholder causes a considerable and continuing failure percentage. Also, that with the latest Special Quality valves there are more chances of equipment failures being caused by other components, so there can be no real objection to a system which precludes valve replacement as a maintenance practice.

Equipments are already in use employing wired-in subminiature, miniature and noval types, and in the future the transistor will also take its rightful place, filling a need that in many cases cannot be met by the thermionic valve.

High-density Polythene

A NEW grade of polythene to be known as "Alkathene H.D." has been put into production by the I.C.I. high-pressure process. Its electrical properties are the same as those of standard "Alkathene 20," but it has greater mechanical stiffness and tensile strength, and the softening point has been raised from 83°C to 116°C. At low temperatures the brittle point is below −70°C, compared with −30°C for standard "Alkathene."

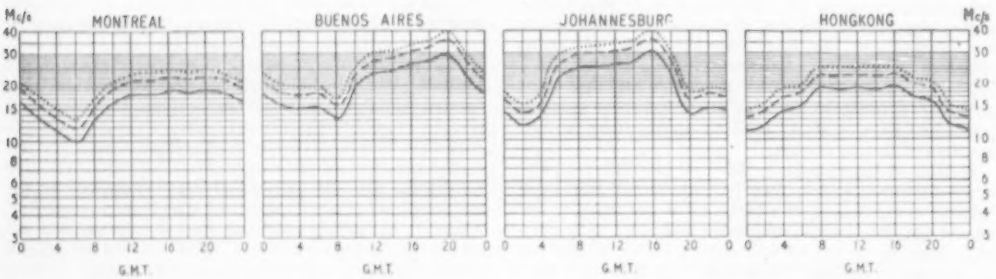
The higher density (0.94 compared with 0.92 gm/cc) is accompanied by lower permeability to gases and vapours and by greater resistance to oils and fats.

For electrical applications one of the principal advantages is the possibility of thinner and tougher coverings for wires and cables, and higher working temperatures.

Limited supplies will be available this year for trial at 4s per lb, irrespective of quantity.

SHORT-WAVE CONDITIONS

Predictions for May



THE full-line curves given here indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during May.

Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.

DATA for the Designers File

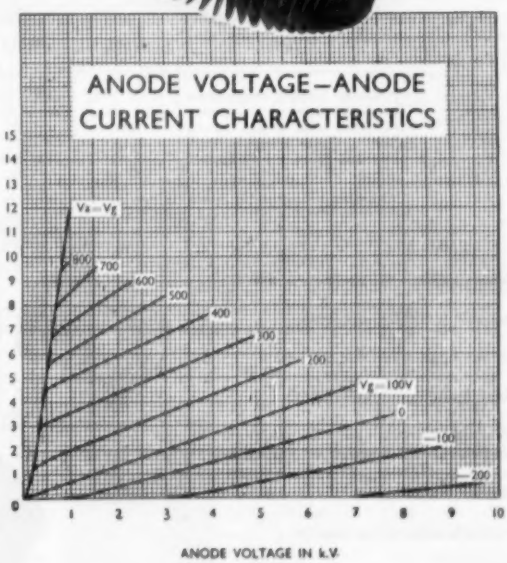
The Ediswan ESA.1500 is of particular interest to Designers of Industrial R.F. heating equipment.

This modern valve, the Ediswan ESA.1500, is a directly heated, forced air cooled, thoriated filament triode primarily intended for operation as an Oscillator in R.F. heating equipment. It may also be used as an R.F. or A.F. power amplifier.

RATING

Filament Voltage (volts)	V_f	8
Filament Current (amps)	I_f	26
Maximum Anode Voltage (volts)	V_a (max)	5,500
Maximum Usable Filament Emission (amps)	F_{em}	6
Maximum Anode Dissipation (kW)	W_a	2.5
Mutual Conductance (mA/V)	g_m	*7.5
Amplification Factor	μ	*24
Anode Impedence (ohms)	r_a	*3,200
Maximum Operating Frequency at full rating (Mc/s)		40
R.F. Power Output (kW)		6

* Taken at $V_a = 5{,}000$v; $I_a = 400$ mA.



THE ESA. 1500 IS USED IN THE RADYNE MODEL C.50, 6 KW INDUCTION HEATER.

The Radyne C.50 induction heater has ample heat reserve for almost all brazing and soldering operations and can handle shrinking on, through heating and small hardening or melting jobs.
Maximum output current is over 1,000 amps.

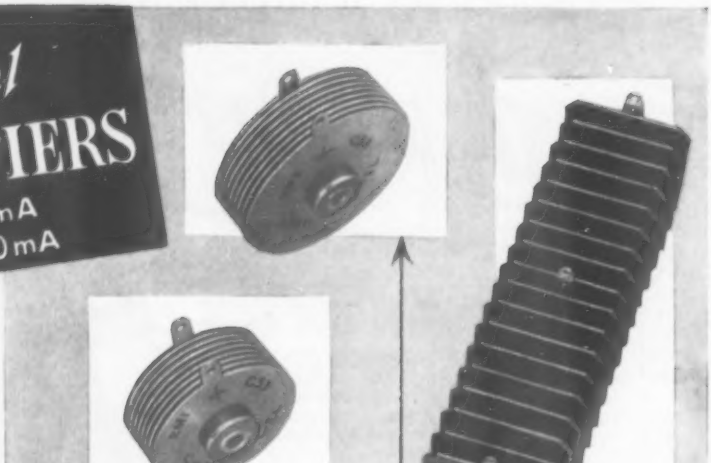
EDISWAN

INDUSTRIAL AND TRANSMITTING VALVES

THE EDISON SWAN ELECTRIC CO. LTD.
155 CHARING CROSS ROAD, LONDON, W.C.2
Member of the A.E.I. Group of Companies

SenTerCel H.T. RECTIFIERS

from 125V 30mA to 250V 300mA

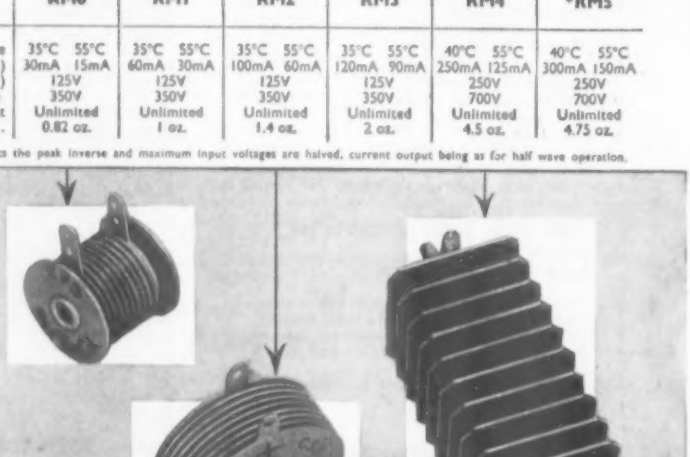


Specially designed for use in domestic Radio & Television receivers, these miniature rectifier stacks have an established position with manufacturers to whom reliability, small dimensions and low costs are important.

TYPE	RM0	RM1	RM2	RM3	RM4	*RM5
Maximum ambient temperature	35°C 55°C	35°C 55°C	35°C 55°C	35°C 55°C	40°C 55°C	40°C 55°C
Maximum output current (mean)	30mA 15mA	60mA 30mA	100mA 60mA	120mA 90mA	250mA 125mA	300mA 150mA
Maximum input voltage (r.m.s.)	125V	125V	125V	125V	250V	250V
Maximum peak inverse voltage	350V	350V	350V	350V	700V	700V
Max. instantaneous peak current	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited
Weight	0.82 oz.	1 oz.	1.4 oz.	2 oz.	4.5 oz.	4.75 oz.

*For use in voltage doubler circuits the peak inverse and maximum input voltages are halved, current output being as for half wave operation.

- Instant starting—no warming-up period
- Unlimited instantaneous overload
- No limit to size of reservoir capacitor
- Simple mounting—no valve holder
- Withstand overloads such as charging current of de-formed electrolytic capacitors
- Low heat dissipation
- Practically indestructible in service
- Simple wiring—two connectors only
- Small size . . . low weight
- Low cost



SELENIUM SenTerCel RECTIFIERS

Standard Telephones and Cables Limited

Registered Office : Connaught House, Aldwych, London, W.C.2

RECTIFIER DIVISION: EDINBURGH WAY · HARLOW · ESSEX

Telephone : Harlow 26811 Telegrams : SenTerCel, Harlow, Essex

Heads, Tails and Noise

By "CATHODE RAY"

LONG, long ago, in the very early days of broadcasting, I remember being quite amused because someone proposed to fit what he called a volume control to a receiver. Readers who are not well versed in ancient history will need to have this joke explained to them. It is just that in those days there was never any spare volume to control. The programme could only be heard at all by making everyone keep quiet and carefully adjusting the "reaction" knob to the very brink of oscillation. Any reduction in volume that even the hopeful enthusiast seemed likely to need was obtainable by slightly reversing the adjustment.

Since then, amplification has been so much developed—and the power of transmitters so much increased—that the problem is less to bring the wanted programme in than to keep everything else out. A very familiar part of that problem is the keeping of other programmes out. Another part of it is that although, technically, there is hardly any limit to the amount of amplification that can be provided, a limit is very soon reached to the amount that can usefully be employed. That limit is imposed by noise.

Simple Probability Theory in the Movements of Free Electrons

To the general public, noise is something one hears. It would, therefore, surprise them to see it defined (in B.S. 204:1943) as "unwanted energy." The full definition is

> Unwanted energy (or the voltage produced), usually of random character, present in a transmission system, due to any causes.

This says nothing about sound or hearing, or even loudspeakers. And why "transmission system?" To explain that last point first, it should be understood that it covers the whole of any system of electrical communication, and not only what is usually called the transmitter—more accurately, the sender. If the system happens to be a telephone or sound broadcasting, the end-product of the unwanted energy is what the non-technical person understands by "noise." The communications engineer uses that word to denote the cause of the sound—the unwanted energy, in fact—rather than the sound itself. But unwanted energy, even if of a random character and present in a transmission system, does not necessarily cause a sound. Its effects can be shut off by disconnecting the loudspeaker, or may emerge in quite a different form on the screen of a television tube, without making any difference to the unwanted energy. So to the radio engineer there is nothing incongruous in referring to a grainy TV picture as "noisy." And, of course, radar operators are familiar with the silent noise that drowns weak echoes (also silent!).

One class of technical noise is termed "man-made" (in which "man" embraces "woman"). Another is caused by thunderstorms and other large-scale natural phenomena. But even if man were to cease from troubling and the weather were at rest there would still be an irreducible barrier of noise, caused by small-scale natural phenomena, known as fluctuation noise, thermal-agitation noise, Johnson noise, shot effect, and Schottky noise. These are not all different. "Fluctuation noise" covers two main kinds, the first being due to the ceaseless jostling of electrons in resistors and known alternatively as thermal-agitation or Johnson noise, and the second is due to the electronic nature of current in valves and is called shot effect or Schottky noise. I have already written about them at some length, but as that was years ago* and the present development of f.m. broadcasting is directing attention to the suppression of noise it may not be out of place to look at the nature of fluctuation noise again.

One can deduce quite a lot about thermal noise in resistors from basic principles. Readers who have not gone into this before may be surprised and perhaps rather mystified to learn that the basic principles particularly concerned are the first and second laws of thermodynamics. The first law is that there is a fixed rate of exchange between heat energy and mechanical energy. When a substance receives heat its store of mechanical energy is thereby increased. If the substance started to fly about the room one could easily believe it. Sometimes it actually does just that—if the temperature rises sufficiently to make the substance boil. If it remains solid there seems to be no evidence of mechanical energy. But its very solidity is an illusion. A cumulus cloud looks solid and clear-cut and rigid at a distance, but on close acquaintance turns out to be mere swirling mist. And if we could get an atom's eye view of a solid wire it, too, would be seen to have plenty of room for mechanical movement within itself. Electrons would be ricocheting about in all directions, and what happened to the incoming heat energy would at once become clear. It is stored as energy of movement (kinetic energy) throughout the substance. The higher the temperature the more energetic the movement.

We can see that the substance as a whole is not moving, so the movements of its particles must be like the movements of people forming a crowd which as a whole remains stationary—they must be random, those in any one direction being more or less cancelled out by movements of other particles in the oposite direction.

So far as we are concerned, the most important part of this description is the phrase "more or less." For any movement of electrons is an electric current.

*Wireless World, May and June, 1952.

So long as exactly equal numbers of electrons are moving in opposite directions the currents cancel out so that none can be detected externally. That could hardly happen all the time unless it were organized. But the only system about their movement is the complete absence of system; their movements are perfectly random. There is nothing whatever to ensure that they would never happen to be all moving in the same direction at the same time, causing a colossal electric current. The future of such an entirely uncontrolled regime might seem to be quite hopeless to predict, yet in fact it can be foretold with incomparably greater confidence than things which are supposed to be under control, such as the economic state of the country. (Is it possible that the anarchists have got something, after all!)

No Exact Balance

This is such an interesting point that it will be worth coming back to, but in the meantime let us just assume that because the heat-generated or thermal movements of electrons in a substance are random there is seldom an *exact* balance between those moving one way at any moment and those moving the opposite way. Mostly there is a slight excess one way or the other, fluctuating all the time. Any net movement of electrons between the two terminals of a resistor is an electric current, and it sets up a difference of potential between those terminals. Fortunately, these currents and voltages are small, but if extensively amplified they are sufficient to be heard in a loudspeaker, which, of course, is how they came to be termed "noise." The type of sound is usually likened to an escape of steam.

The chief thing we want to know about it is how to stop it, or at least reduce it to a minimum. Because the first law of thermodynamics tells us that the noise energy is directly proportional to the heat, an obvious suggestion is to remove all the heat from the parts of circuits that are followed by sufficient amplification to make the noise a nuisance. This necessitates reducing their temperature to -273°C, so it is an entirely unpractical idea. Even if we were to take the trouble to keep the equipment in the "fridge" and thereby risk domestic strife, the reduction would be only about one tenth or less, so hardly worth it. The noise power is, in fact, proportional to the absolute temperature (°K) which is the number of centigrade degrees above -273.

How does it depend on the resistance of the circuit? We can get a clue from the second law of thermodynamics, which says that heat can't go from one body to a warmer one without, as it were, some "heat-motive force." So if we connect two resistors at equal temperature in parallel, as in Fig. 1, each must deliver to the other noise energy at the same rate, whatever their resistances. For if the energies didn't balance there would be a transfer from one to the other and one resistor would become warmer and the other cooler. Even without any laws of thermodynamics we could guess that this couldn't happen, for any single resistor can be considered as two in parallel, by splitting it endwise, and if we consider in turn different cleavages the idea can easily be reduced to an absurdity.

But let us take two separate resistors, R_1 and R_2 in Fig. 1(a), connected in parallel, then calculate the noise power each delivers to the other, and make use of our knowledge that these powers must be equal. To make current flow in this circuit it is necessary to have an e.m.f. Each of the innumerable flying electrons can be regarded as a miniature e.m.f., but to save time we shall lump all those in R_1 together as a fluctuating e.m.f. E_1, driving a noise current I_1 into R_2; and similarly for R_2, as in Fig. 1(b). By the principle of superposition, these currents can be considered separately.

The power developed in a resistance R by a difference of potential V across its terminals is V^2/R. The p.d. across R_2 due to E_1 is, of course, $E_1R_2/(R_1+R_2)$, so the power in R_2 is $E_1^2R_2^2/(R_1+R_2)^2R_2$, or $E_1^2R_2/(R_1+R_2)^2$. Doing the same for R_1 and equating the powers:

$$\frac{E_1^2R_2}{(R_1+R_2)^2} = \frac{E_2^2R_1}{(R_1+R_2)^2}$$

So

$$E_1^2R_2 = E_2^2R_1$$

and

$$\frac{E_1^2}{R_1} = \frac{E_2^2}{R_2}$$

In words, the square of the equivalent noise e.m.f. divided by the resistance is the same for resistors 1 and 2. But this principle would obviously apply to any resistors, so we can say that noise e.m.f. squared, divided by resistance, is a constant. Remember, however, that we have been assuming that the resistors are at the same temperature. There is also a complication arising from the fact that thermal noise power, being completely random, occurs equally at all frequencies, and in practice one can only measure it over a limited band of frequencies at a time. For one thing, noise at the very highest frequencies would always be reduced by stray capacitance across the resistance. So a second condition for E^2/R being constant is that E must be reckoned across the same band of frequency. This qualified constant, to which E^2/R is equal, is in fact

$$4kTB$$

where T is the absolute temperature, B is the bandwidth in c/s, and k is a real constant, called Boltzmann's, of value 1.38×10^{-23}. Put another way, the noise voltage $E=\sqrt{4kTBR}$.

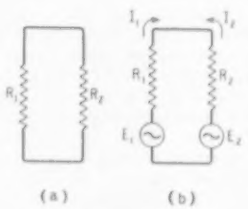
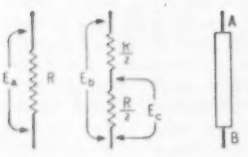


Fig. 1. Any resistor is a noise generator, so if two are connected in parallel (a) each will deliver noise power to the other. Working from the principle that the exchange of power must be equal, one can easily show that each noise e.m.f. in the equivalent circuit (b) must be proportional to the square root of its own resistance.

If you preferred, instead of the equivalent voltage generators in series as in Fig. 1(b) you could have used the equivalent current generators in parallel with R_1 and R_2, delivering noise currents to R_1 and R_2 inversely proportional to their resistances. This works out, in a somewhat similar manner, to $I_1^2R_1=I_2^2R_2$, showing that in general I^2R is constant, or the noise current is proportional to $1/\sqrt{R}$. The same conclusion is reached from the previous re-



(a)

Fig. 2. *Fig. 2. From the result of Fig. 1 it is clear that adding together two equal noise voltages gives a total that is not twice that of either but $\sqrt{2}$ times.*

(b)

Fig. 3. *Fig. 3. The noise problem in a resistor is simplified by assuming that the movements of electrons inside it are all from A to B or from B to A.*

sult simply by substituting IR for E, in accordance with Ohm's law.

It is a very well-known fact that the power delivered by a generator to a load is greatest when the load resistance is equal to the generator resistance. The generator e.m.f. (say E) is then equally divided between generator and load, so that the terminal voltage is E/2. The maximum power into load resistance R is therefore $(E/2)^2/R$. Applying this to our noise-voltage $E = \sqrt{4kTBR}$ we get as maximum power kTB. The interesting thing about this is that it doesn't depend at all on the size of the resistor responsible for the noise, or how many electrons it has inside to generate the noise. But remember that the maximum noise *voltage* is obtained when the resistor is open-circuited, and is then equal to E, which is not the same for all resistors but is proportional to the square-root of their resistance.

Another interesting thing can be gathered from Fig. 2. It is obvious that E_b must be equal to E_a, because two resistances R/2 in series are identically the same as R. It might also be supposed than E_b was twice E_c, seeing that two voltages in series, each equal to E_c, add up to E_b. But whereas $E_a = \sqrt{4kTBR} = E_b$, $E_c = \sqrt{4kTBR/2}$, so

$$E_c = \frac{E_b}{\sqrt{2}} = 0.707E_b$$

not half E_b. The reason, of course, is that the noise voltages developed by different portions of a resistor are entirely unrelated; sometimes they may happen to add up directly, sometimes they may cancel one another completely out, and most of the time they are somewhat between. As we saw some time ago,* when two alternating voltages in series are liable to have all possible phase relationships, their *squares* add up. In Fig. 2(b), then

$$E_b^2 = E_a^2 + E_c^2$$

or

$$E_b = \sqrt{2}\,E_c$$

which is the same as we found as a consequence of the relationship between resistance and noise voltage, which in turn followed from the second law of thermodynamics. As power is proportional to voltage-squared, it is true to say that noise *powers* add up directly.

And now we can get back to the question that may have been puzzling some people: how is it that currents and voltages that arise purely from chance can be so definite that their values can be calculated from the simple formulæ we have seen? A full answer would fill a book†; but we might have just about enough space left here to get a rough idea.

An ordinary piece of conducting material, such as a resistor is made of, consists of a stationary pattern of atoms, with vast numbers of electrons flying about in the spaces between. Although most of the material is empty space, the electrons are moving so fast at earthly temperatures that they are continually colliding with the atoms and being deflected into some other direction. The whole thing being more chancy even than a roulette wheel, all directions are equally likely, and one can base calculations on that assumption.

What we are interested in is the net movement of electrons towards or away from either terminal, because that is what causes the trouble. In Fig. 3 the terminals of a resistor are marked A and B. Electrons moving horizontally have no effect and those moving vertically have maximum effect, while intermediate directions are intermediately effective according to the angle. This complication can be taken care of in the mathematics, but to simplify the picture let us imagine that all electrons are moving vertically, either up or down.

Suppose at first that there was only one electron, and somebody was making a note of its direction at regular intervals of time. This situation would be similar to someone repeatedly tossing a coin at random and noting the result of each throw. At any one throw a head or a tail would be equally likely. That does not mean that in any even number of throws heads and tails would always come in equal numbers. In any two throws there are four equally likely possibilities; (1) HH, (2) HT, (3) TH, (4) TT. So two of the same are just as likely as one of each. In three throws there are eight equally probable results, because each of the foregoing four gives rise to two alternatives, depending on whether the third throw yields a head or a tail. Out of these eight, only one is all heads and only one all tails. This process can be continued indefinitely, and mathematical methods have been devised to enumerate the probabilities beyond the point at which it becomes too tedious to write down all the possible results of a sequence of throws. The greater the number of throws, the smaller the proportion that are likely to be all of one kind and the greater the tendency to average out at equal numbers of each.

Odds and Probabilities

This does not mean that an *exactly* half-and-half result ever becomes highly probable, because the greater the number of throws the greater the number of alternative possibilities. Although the most probable result of a million throws is exactly half a million of each (so that one would be justified in calling this the "normal" result) the odds are in fact 1,770 to 1 against it. Deviations from normal of up to about 100 each way are almost equally probable. Much beyond that, the probabilities fall off very steeply—see Fig. 4—and soon become fantastically small. The chance of getting 502,000 heads in a million is 97,000 to 1 against, and 505,000 heads is 130,000,000,000,000 to 1 against! So although theoretically there is a possibility that a million consecutive throws might yield a million heads,‡ with large numbers one can entirely ignore

*"Total Power," *Wireless World*, March 1952.

†A good one to study is "Frequency Analysis, Modulation and Noise," by S. Goldman (1948, McGraw-Hill Book Co.).

‡Merely to write down the number representing the odds to 1 against, at the rate of two figures per second, would take 60 solid hours! To describe such a number as astronomical would be a super-lative understatement.

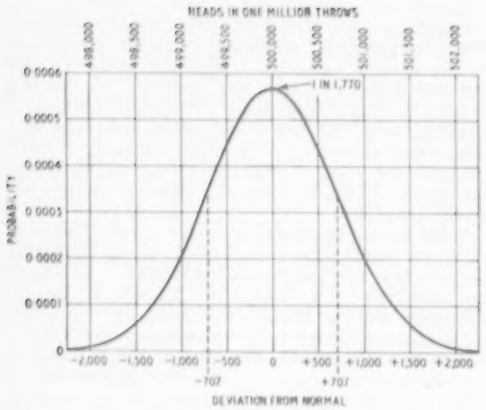


Fig. 4. This graph shows the probability of obtaining a given number of heads in a million random tosses of a coin. For numbers differing more than about ½% from half a million the probabilities are too small to show. The same graph applies to tails—and to the number out of a million electrons moving in one of two equally probable directions. ± 707 is the r.m.s. value of the deviations from normal, taken over a period of time.

the possibility of any but very small deviations from normal.

Still, these small deviations are important, because they are the basis of our noise. The pattern of probabilities for a million tosses of a coin applies equally to a million electrons moving up or down. At any given moment, the odds are 1,770 to 1 against exactly equal numbers moving in each direction. Nearly all the time there is an excess one way or the other; this fluctuating excess is noise. The odds are even more heavily against the excess ever being more than a very small proportion of the total number of electrons involved. So if at any time you decide to make a spot check of instantaneous noise current you are almost certain to find it between quite narrow definable limits. Fig. 4 shows that in a gathering of a million electrons the noise current is less than 2,000 electrons (one-fifth of one per cent) nearly all the time. In any significant part of a circuit there are vastly more than one million electrons, and the greater the number the smaller the percentage excess likely to occur one way or the other.

It must be remembered that the Fig. 4 pattern (called, incidentally, a Gaussian or normal error distribution) shows the most probable values of *instantaneous* noise current. From the fact that they are symmetrical about zero, we can gather that over a period of time the positive and negative values will average out, which means that noise has no long-term d.c. component.

Fig. 4 also shows that the *peak* noise current, even over quite a long period, is unlikely to exceed say one per cent of the theoretically possible one million electrons. The smaller percentages of larger numbers of electrons can easily be calculated from the Gauss formula used for plotting Fig. 4.*

But what would be even more helpful is the r.m.s. value, because that is the value which, when squared, represents noise power, and, as we have seen, separate noise powers can be added directly to give total noise power. Calculating the r.m.s. value from mere probabilities might seem to be a rather difficult and not altogether reliable enterprise. But although the r.m.s. value of the fluctuations itself fluctuates appreciably if it is reckoned over a short period, over a long period (such as a second or two!) it remains steady enough to be given a definite figure. And this figure agrees well with measurements. By means of mathematical manipulation that can be found in the appropriate books, such as the one I mentioned, it can be shown that it is equal to the square root of the average number of electrons going one way (i.e., half the total electrons). So for Fig. 4 it would be 707.

The r.m.s. number of excess electrons is, of course, not by itself a value of current. To determine the current one has to know how fast the electrons are moving so as to calculate how many are passing a given point per second.* That is where the temperature comes in; the higher the temperature, the faster the electrons move. It is also where the resistance comes in. Just how it comes in does not immediately spring to the mind, unless your mind works a good deal faster than mine. But it can be arrived at in stages, like this:

Let D denote the r.m.s. value of the electron fluctuation. If we have looked up the right book we will have seen that by purely mathematical processes D is equal to $\sqrt{n/2}$, where n is the total number of electrons in circulation. Now the conductivity of a material is proportional to the number of circulating electrons per unit of volume. Assuming the length of the piece of circuit in question is l and that it has a uniform cross sectional area A, its volume is lA, so its conductivity is proportional to n/lA. Its resistivity ρ is just the conductivity upside down, so

$$\rho \propto \frac{l\mathrm{A}}{n} \qquad \therefore \quad n \propto \frac{l\mathrm{A}}{\rho}$$

And therefore, substituting $\mathrm{D} = \sqrt{n/2}$ we have

$$\mathrm{D} \propto \sqrt{\frac{l\mathrm{A}}{2\rho}} \propto \sqrt{\frac{l\mathrm{A}}{\rho}}$$

But the resistance $\mathrm{R} = \frac{l\rho}{\mathrm{A}}$, so $\rho = \frac{\mathrm{AR}}{l}$

$$\therefore \ \mathrm{D} \propto \sqrt{\frac{l\mathrm{A}l}{\mathrm{AR}}} = \frac{l}{\sqrt{\mathrm{R}}}$$

The number of fluctuating electrons per unit length of circuit is of course D/l, and if they are moving at the rate of v units per second the number to pass a given point per second (to which the r.m.s. noise current I is proportional) is Dv/l. And v is proportional to the absolute temperature T, so

$$\mathrm{I} \propto \frac{\mathrm{D}v}{l} \propto \frac{\mathrm{DT}}{l}$$

Lastly, substitute $\mathrm{D} \propto l/\sqrt{\mathrm{R}}$ from above, and

$$\mathrm{I} \propto \frac{l}{\sqrt{\mathrm{R}}} \cdot \frac{\mathrm{T}}{l} = \frac{\mathrm{T}}{\sqrt{\mathrm{R}}}$$

So the upshot of all this is that the r.m.s. noise current is proportional to the absolute temperature and inversely proportional to the square root of the resistance. And wasn't I relieved to find it worked out in agreement with the previous results!

*The probability of a deviation d from the average $n/2$ in a number n is $\exp.-d^2/n \over \sqrt{\pi n}$

*6,242,000,000,000 of them per second make one microamp.

More Lines *Instead of* Colour?

Higher Definition Should Come First

By D. A. BELL, M.A., Ph.D.

THE defence of the 405-line system by V. J. Cooper (*Wireless World*, April, 1956, p. 173) rests on three main arguments:

(*a*) Bandwidth is limited, and the "value" of television does not justify the use of any greater bandwidth than at present.

(*b*) For a given number of lines, it is useful to employ a greater bandwidth than is calculated on the traditional basis of a half-cycle per picture point.

(*c*) "Economic factors must surely be predominant in deciding standards."

As regards (*b*), the present writer has argued[1] that on theoretical grounds, for the perfect reproduction of all signal waveforms, the traditional minimum bandwidth should be doubled, not merely increased by 50%. But this still does not tell us the subjective difference between two systems which differ both in number of lines and in relative bandwidth. In reply to (*a*), some might say that the programmes offered are so valueless that no bandwidth at all should be devoted to television broadcasting: anyone eccentric enough to want this kind of thing should pay for a wire relay system. Alternatively, one can say that some of the programmes are very good, and deserve to be presented more adequately than is possible with 405 lines; and in consequence the use of 3 Mc/s to transmit these programmes inadequately, instead of 10 Mc/s to do them justice, is in fact a waste of the 3 Mc/s.

But the crux of the matter is the viewer's judgment of the picture on the home receiver. During a recent visit to France, the writer went into the lounge of an hotel in Grenoble to glance at the television and was astonished at the detail and the absence of visible lines. One knew that at the end of the war an 819-line system was developed in France, in addition to the earlier 441-line system, but the writer had overlooked the fact that the whole of French television is now on 819 lines and not on the "European" standard of 625 lines. This choice by the French authorities is justified by the fact that one glance at the received picture brought conviction that the system producing it could be nothing less than the 819-line system. Its standards are as follows: 819 lines, with interlace; 25 complete pictures per second; fly-back time, 10%; video passband, 10.5 Mc/s; separation between vision and sound carriers, 11.15 Mc/s; nominal channel width (including guard bands), 14 Mc/s; carrier-frequency range, 164 to 200 Mc/s.

At the beginning of 1956 there were 10 transmitters operating, as listed in descending order of e.r.p. in the table, and it is planned to increase this number to 37 by the end of 1958. The powers used are affected by geographical conditions as well as by the area of population to be covered, and the programmes seen in Grenoble had been relayed from the local 300-watt transmitter which is on a 7,500-ft mountain situated 15 km from the centre of the town. It was true to say that interference was negligible, and in particular car ignition interference was not seen, though on occasion a very fine moire pattern could be detected by looking closely.

The great advantage of the higher definition is that large-scale effects can be presented with adequate detail, e.g., a display of massed folk-dancing—and solo artists are normally presented as three-quarter-length or full-length portraits, not head-and-shoulders only. It liberates television from the state of being a specialized art having limited effects at its disposal in order to *represent* some form of entertainment, and makes it as free as the black-and-white film to *reproduce* visual entertainments where so desired, or use more natural "shots" if the moving picture is regarded as an artistic work. The standard sizes of picture tube in France are 17in and 21in, which is comparable with the size of picture presented by the 16-mm cinema in the home, and in spite of all arguments about optimum angle of vision seems pleasing. On the other hand, the camera craft in some of the programmes seen by the writer was poor by British standards. Camera shading effects were common, and on one occasion a switch to a second camera turned the picture temporarily into a soot-and-whitewash display that was almost unrecognizable. A difficulty associated with high definition is that when an announcer, for example, is shown seated in the centre of the picture, there is a large expanse of plain background in the picture. On some occasions flicker was just perceptible on this high-light area. It is just possible that this may have been due to external interference, but it could be due to the fact that the sensitivity of the eye to flicker increases with brightness level: it has been claimed[2] that a European television image on 50 c/s must not exceed one-sixth of the brightness which could be used on an American 60 c/s image for freedom from flicker. This is merely another point to watch in studio

[1] D. A. Bell. Economy of Bandwidth in Television, *J. Brit. I.R.E.*, **13** (1953) 447.

[2] C. J. Hirsch. Television in the World Today, *Electrical Engg.*, **75** (1956) 321.

TABLE I

Transmitter	E.R.P. (Vision)
Lille	200 kW
Paris	100 kW
Marseille	50 kW
Strasbourg	20 kW
Grenoble	300 W
Reims	300 W
Lyons	100 W
Metz	100 W
Nancy	100 W
Dijon	50 W

technique, avoiding large high-light areas when the field of view is enlarged.

The French television service is entirely government operated, and the licence fee is 4,500 francs. At the official exchange rate this is about £4 10s, but in terms of food prices and wages it might well be argued that 4,500 francs does not, in practice, mean more than our fee of £3. The number of receivers has been increasing exponentially, is now about 300,000, and is expected to saturate at about 4½ million: this would represent one television receiver for every three homes. Programmes are a matter of personal taste, but on a small sample they seemed a fair mixture of travel film, news, political interview and variety show, with perhaps more political interview and comment than we have.

What is the moral of this for the British viewer? In 1945 there were arguments for retaining 405 lines and arguments for a system around 600 lines, but the French results have made it clear that we ought to be planning now for 819 lines. Unfortunately the present plans for I.T.V. and for B.B.C. alternative programmes have allocated Bands II and III, and if we install a 405-line service in both these bands we shall have made it virtually impossible for Britain to have a high-definition television service within the foreseeable future. Instead, there is talk of introducing colour because there is a method of making that "compatible." In the past, in such controversies as f.m. versus a.m. sound and high- versus low-definition television, it has always been argued that it is important to avoid anything which would greatly increase the cost of a receiver. This was Cooper's final argument in defence of 405 lines. But can it be said that the introduction of colour satisfies this criterion? It can rather be suggested that whereas increasing the i.f. bandwidth and the timebase speeds is a routine operation, the design of a compatible colour receiver involves such fun and games for the research engineer that he regards the result as a notable contribution to technical progress—and, broadly speaking, the cost to the purchaser will be in proportion to the amount of technical ingenuity which the designer has to exercise. The following table (based on data published in

TABLE 2

R.F. Stage:— No. of models	Cascode 57		Single pentode 5		Unspecified 3	
No. of I.F. Stages ..	2	3	4	5	6	
No. of models ..	6	24	25	7	3	

La Télévision Pratique, Jan., 1956) gives an idea of the effect of the greater bandwidth on the design of commercial television receivers: in comparing with British practice, it must be remembered that these are all operating in Band III.

The majority of these receivers claim a bandwidth of 9 to 10 Mc/s, and the few with only two i.f. stages are described specifically as local-station receivers. A noticeable design feature is that the difference between medium- and long-range receivers (the latter being for 50-75 miles range) is in the elaboration of the synchronizing circuits rather than in the amount of gain provided.

The specifications of these French receivers confirm that there is no serious economic problem in the design of a wide-band television receiver, and if colour television in any form can be contemplated the economic argument has been so thoroughly abandoned that it is a red herring to drag it up in connection with standards of definition. It seems to be agreed that the proposed system of compatible colour could be applied equally to transmissions on higher definition than the present British and American standards, and the question is whether the introduction of colour is more urgent than the raising of definition. Having seen high-definition transmission, under typical user conditions in which a standard commercial receiver was operated by persons with no technical knowledge, the writer has no hesitation in saying that high definition should come before colour. When you go to the cinema, do you look to see whether the film is in colour before you decide to go to a particular film? Do you even remember how much of the last film programme you saw was in colour? Unless your answers to these questions are very different from the writer's, you ought to be asking whether it is right to pursue the expensive luxury of colour while accepting in perpetuity the limitations imposed by 405 lines.

CLUB NEWS

Barnsley.—"Crystal-controlled convertors" is the subject of the talk to be given by H. Eyre (G5KM) to the Barnsley and District Amateur Radio Club at 7.0 on June 8th at the King George Hotel, Peel Street. Sec.: P. Carbutt (G2AFV), 33 Woodstock Road, Barnsley.

Birmingham.—The June meetings of the Slade Radio Society will be held on the 8th and 22nd. At the first meeting D. W. Morris will deal with industrial electronics and at the second a member of the staff of Mullards will speak on "Oscilloscope design and applications for amateur use." Both meetings will be held at 7.45 at The Church House, High Street, Erdington. Sec.: C. N. Smart, 110 Woolmore Road, Erdington, Birmingham 23.

Bromley.—On June 1st, George Hicks (G4JP) will speak at the meeting of the Bromley Radio Club on "R.C.A. high-fidelity sound amplification." Meetings are held at 8.0 at the Shortlands Hotel, Station Road, Shortlands, Kent.

Chelmsford.—At the June 14th meeting of the Chelmsford group of the British Amateur Television Club, F. Turner will speak on 70-cm transmitters. The meeting will be held at 7.30 at 10 Baddow Place Avenue, Great Baddow. Sec.: D. W. Wheele (G3AKJ), 56 Burlington Gardens, Chadwell Heath, Essex.

Newcastle.—The next meeting of the North East Amateur Transmitting Society will be held on June 5th at 7.45 at the Liberal Club, Pilgrim Street. Sec.: O. W. Docherty, 130 Grainger Market, Newcastle-upon-Tyne 1.

Servicing Exams : Record Entry

A TOTAL entry of 822 candidates for this year's examination for the Radio Servicing Certificate, for which the practical test was held on May 12th at 41 centres, is announced by the Radio Trades Examination Board. This is an increase of approximately 60% on the 1955 figure—the previous record.

A condition of entry for the examination for the Television Servicing Certificate is that the entrant must hold the Radio Servicing Certificate and the number of entries is therefore considerably smaller. The total of 137 is, however, an increase on previous years. The practical test is on June 16th.

Both these servicing certificate examinations are conducted jointly by the City and Guilds of London Institute and the R.T.E.B. (9 Bedford Square, London, W.C.1) from whom particulars of future examinations are obtainable.

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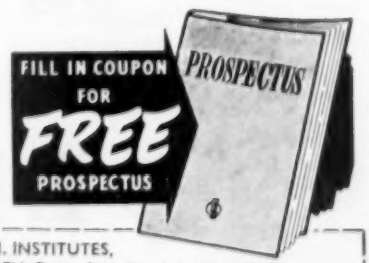

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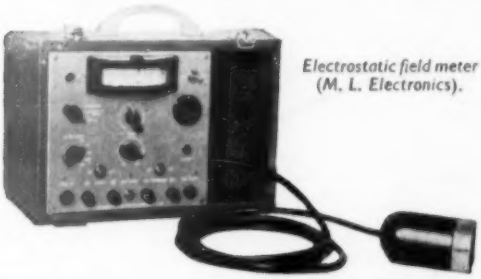
Electrostatic Field Meter

FIRE and explosion hazards associated with the fortuitous generation of high electric field strengths in many manufacturing processes are reduced if early warning of the growth of the field can be given. In the meter made by M. L. Electronics, Ltd., Holly Road, Twickenham, Middlesex, separate output terminals are provided



Electrostatic field meter (M. L. Electronics).

from which a signal is applied to any form of alarm relay when the field strength exceeds a predetermined level.

The potential developed on a probe electrode is modulated by alternately exposing and shielding the electrode by an earthed rotating shutter. After amplification the signal is applied to a phase-sensitive detector and measured by a centre-zero instrument which indicates the polarity of the field. The full-scale reading can be varied between 1 and 9 kV/metre and an outlet plug provides 300 volts for calibration purposes. Terminals are also arranged for connection to a recorder.

Television Turret Tuner

A TOTAL of 12 channels is provided in a new television turret tuner recently introduced by Brayhead (Ascot), Ltd., Full View Works, Kennel Ride, Ascot, Berks. The tuner has two valves, a twin-triode neutralized cascode r.f. stage and a pentode-triode mixer/oscillator. The input impedance is 75 ohms.

The aerial coil segments on the turret provide for use of bandpass circuits as these may be required with a high i.f. (35-38 Mc/s) on Band I to ensure trouble-free operation on Channel I, or to give good image signal rejection on Band III with a low i.f. Bandpass circuits are used also between the i.f. and mixer stages.

Oscillator injection is by a combination of inductive and capacitive couplings, while drift is compensated for by means of negative-temperature coefficient capacitors. On Band I these limit the drift to −85 kc/s and on Band III to +35 kc/s to −88 kc/s. Fine tuning of the oscillator (concentric with the turret-operating spindle) allows for a variation of 700 kc/s on Band I and 3 Mc/s on Band III. Coils are mounted radially and cores adjusted through holes in the turret.

Although produced primarily for set manufacturers the tuner is available to home constructors.

Moving-coil Loudspeakers

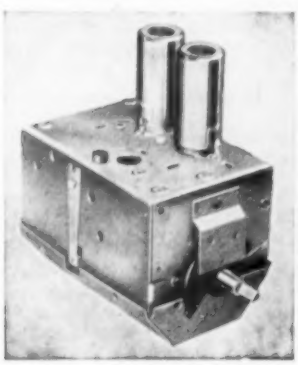
THE Lorenz (German) moving-coil loudspeaker system is now available in this country through Technical Supplies, Ltd., 63, Goldhawk Road, London, W.12. Known as Type LP312-2 it comprises a 12-in low-frequency unit and two 2½-in high-frequency units mounted with divergent axes on a bridge across a diameter of the larger unit. The flux density is 17,500 gauss in each case; but the impedance of each h.f. unit is 5.5 ohms and of the l.f. unit 15 ohms. Component values and a circuit for a suitable cross-over network (2000 c/s) are supplied; also the dimensions of suitable alternative vented cabinets. The nominal overall frequency coverage is 15 c/s to 22.5 kc/s with a power rating (average) of 25 watts. The price is £14 19s 6d (not subject to purchase tax).

The high-frequency unit is available separately for use with existing loudspeakers and costs £1 19s 6d including purchase tax.

Radio-controlled Record Changer

A NOVEL record player with automatic record changing by remote radio control is to be manufactured in this country by Staar Electronics, Ltd., 39, New Oxford Street, London, W.C.1. It takes up to ten records, has four turntable speeds, including 16 r.p.m. for "talking book" records, and can be used with small or large centre-hole records.

A transistorized unit attached to the record changer receives control signals from a hand transmitter unit (battery operated and also using transistors) and enables the operator to reject or repeat records at will. The output for the pickup can also be made to modulate an r.f. output from the receiver ("transcription unit") which is then picked up by a standard radio receiver or radio-gramophone and reproduced in the normal way. A G.P.O. special transmitting licence for radio controlled devices would be required.



Left: Brayhead 12-channel television turret tuner. Above: Staar Electronics record changer and (right) transistorized radio control unit.

TELEVISION IN GERMANY
TRANSMITTERS OPERATING BY END OF 1956
FUTURE TRANSMITTER STATION
RELAY STATION
STUDIO
MAIN CONNECTING BAR
BRANCH CONNECTION
DIRECT RECEPTION
Miles
0 10 20 30 40 50
FLENSBURG
KIEL
BUNGSBERG
HAMBURG
EGESTORF
BREMEN
BREMEN-OLDENBURG
HÖHBECK
BERLIN
MELLENDORF
HANOVER
TEUTOBURGER-WALD
BECKUM
HARZ-WEST
ZONE
EASTERN
LANGENBERG
WUPPERTAL
HOHER MEISSNER
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KREUZBERG-WASSERKUPPE
GROSSER FELDBERG
COBURG
FRANKFURT
CZECHO-SLOVAKIA
BAMBERG
TRIER
KAISERLAUTERN
WURZBURG
NUREMBERG
SAARBRUCKEN
WEINBIET
ZWEIBRUCKEN
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AALEN
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Television in Germany

DEVELOPMENT OF THE WESTERN-ZONE NETWORK—AND ITS LINK WITH BERLIN

By W. NESTEL,* Dr. Ing.

ALTHOUGH an experimental television service was established in Germany as far back as 1936 and a public service had been planned for the end of 1939, the war prevented any further development and it was not until Christmas 1952 that television really became fully available to the German people—to those in the West at any rate. Since none of the pre-war 441-line equipment was available it was possible to adopt the new 625-line C.C.I.R. standard. Reconstruction after the war actually began in 1948, and by the time the service opened the Western-Zone network consisted of five transmitters—at Berlin, Hamburg, Hanover, Langenberg and Cologne—and four studios, one in Berlin, one in Cologne and two in Hamburg. Connections between the studios and transmitters were made by radio links.

This represented the first phase of the post-war development scheme. In planning the further extension of the television network, one of the important things which the authorities have had to bear in mind is the regional and de-centralized nature of cultural life in Germany. There is no one town which has a predominating influence in this respect, so it has not been possible to establish a single main centre for programme production as has been done in Britain and France. The system has been arranged, therefore, so that the existing broadcasting companies in the various big towns supply contributions to a joint programme—a principle which is known as *Fernseh-Sammelschiene* or television "collecting bar." Consequently all the studio centres which have been established for sound broadcasting have now acquired extra equipment for the production of television programmes.

As can be seen from Fig. 1, these studio centres are situated at Berlin, Hamburg, Hanover, Cologne, Bonn, Frankfurt, Baden-Baden, Stuttgart, and Munich. It can also be seen that the television collecting bar is not only a method of operation but a complete chain of radio links (indicated by the heavy black line). As such it will take in programmes from any part of Western Germany, and also distribute the joint programme to the various transmitters. Actually the joint programme only occupies the complete system during the main transmission hours in the evening. Outside of these hours the individual broadcasting companies are at liberty to transmit their own regional programmes, and for this purpose the collecting bar can be split into sections as required.

Most of the radio links in the system work on decimetre wavelengths and Fig. 2 shows a typical relay station housing the directional transmitting and receiving equipment. The link between Höhbeck and Berlin, however, is rather different because it has to pass over nearly 150 kilometres of Russian-occupied territory in a single jump (see Fig. 1). This could not be spanned by decimetre-wave equip-

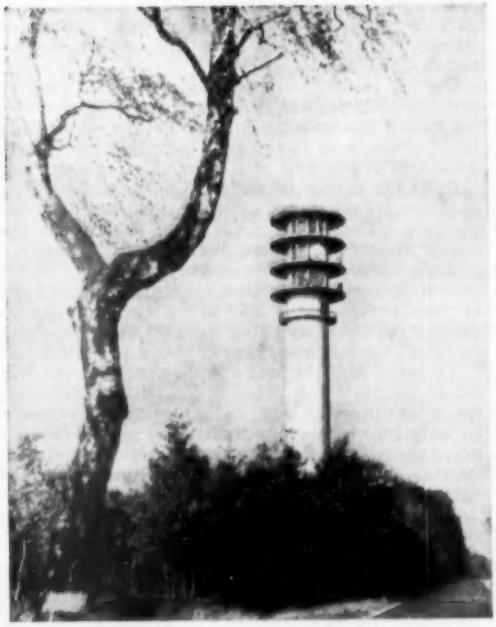
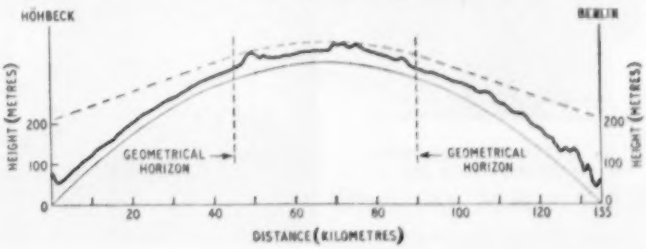


Fig. 2. Decimetre-wave relay station in the "collecting bar" system.

*Nordwestdeutscher Rundfunk, Hamburg.

Left: Fig. 1. Showing the route of the television "collecting bar" in Western Germany, with transmitters and their approximate service areas.



Right: Fig. 3. Cross-section of territory between Höhbeck and Berlin. (The scales in height and distance are not the same, of course.)

ment because on these frequencies it is necessary to have relay stations at intervals of about 50 km, so instead a v.h.f. link has been used, working in the region of 200 Mc/s.

Fig. 3 shows a cross-section of the territory between Höhbeck and Berlin, and it will be seen that the main difficulty is the curvature of the earth acting as an obstacle to line-of-sight propagation. Moreover, this means that the waves have to pass very close to the surface of the earth where tropospheric disturbances can cause severe fluctuations in signal strength. The amplitude of these fluctuations becomes greater the farther the line of transmission extends beyond the geometrical horizon, so it has been necessary to make the radio horizons as far away as possible (that is, as near to the distant station as possible) by using very high masts for the aerials. The masts are actually 492ft high at both ends of the link.

To make sure that the signal strength never falls below the minimum required for reliable operation, the transmitters at both ends (the link is two-way) have the high output power of 10kW, while the directional aerials have the exceptionally high gain (for the 200-Mc/s region) of 500:1. This gives an effective radiated power of 5 megawatts! The transmitters are conventional equipments of the kind used for television broadcasting but the aerials are somewhat unusual, as can be seen from Fig. 4. Each consists of 240 dipoles mounted in groups of eight in front of flat reflectors, and as can be seen from Fig. 5 a very pronounced beaming effect is obtained from the arrangement. The receivers used in the link are specially developed types for relay work, and have a.g.c. circuits, working on the sync-pulse amplitude, which will correct fluctuations of up to 1:10 in the input signal.

Regarding the video equipment of the television collecting bar, each regional centre in the scheme has one studio, a television O.B. van with two or three cameras and a film team using 16-mm equipment. At the two ends of the bar, however, at Hamburg and at Munich, the installations have been made more elaborate so that programmes on a more ambitious scale can be produced. The Hamburg centre, for example, which is in the suburb of Lokstedt, contains three large studios and one small one, together with the appropriate control rooms. If necessary the three large studios can be combined into one by opening the large doors which normally separate them. At Munich the television centre has three studios altogether.

The cameras used in the studios are Super-Iconoscope types requiring a light intensity of nearly

(*Continued on page* 245)

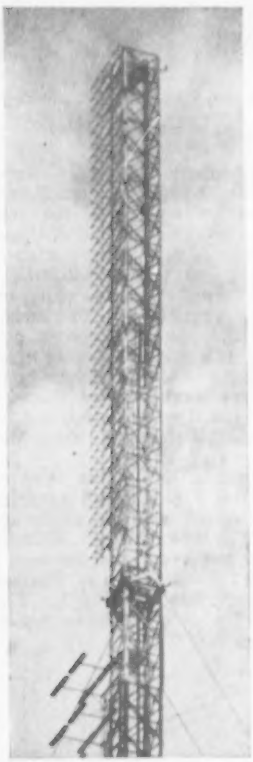
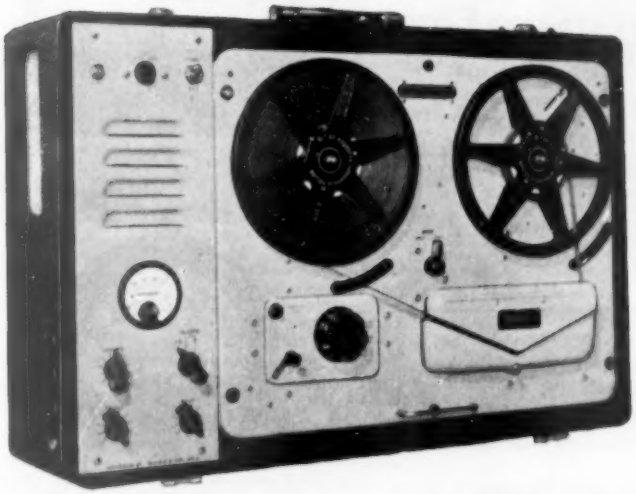


Fig. 4. Directional aerial array of the 200-Mc/s radio link at Berlin.

View of the television studios at Hamburg.

Right: Typical television O.B. van.

VORTEXION TAPE RECORDER



The amplifier, speaker and case, with detachable lid, measures 8¼in. x 22½in. x 15½in. and weighs 30 lb.

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★ The total hum and noise at 7½ inches per second 50-12,000 c.p.s. unweighted is better than 50 dbs.

★ The meter fitted for reading signal level will also read bias voltage to enable a level response to be obtained under all circumstances. A control is provided for bias adjustment to compensate low mains or ageing valves.

★ A lower bias lifts the treble response and increases distortion. A high bias attenuates the treble and reduces distortion. The normal setting is inscribed for each instrument.

★ The distortion of the recording amplifier under recording conditions is too low to be accurately measured and is negligible.

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★ The power output is 3.5 watts heavily damped by negative feedback and an oval internal speaker is built in for monitoring purposes.

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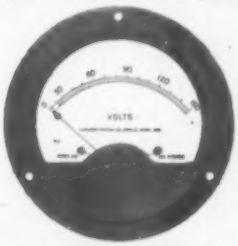

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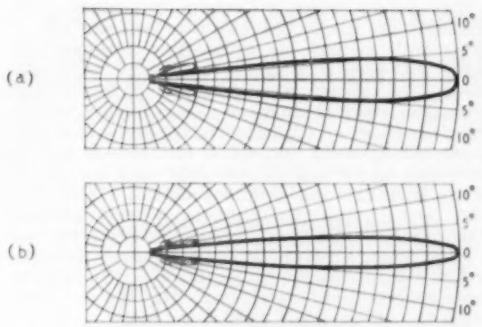
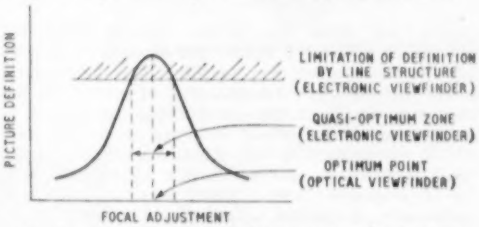


Fig. 5. Polar diagrams showing the radiation patterns, (a) horizontal and (b) vertical, of the directional aerial at Hohbeck.

Fig. 6. Super-Iconoscope camera with optical viewfinder.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QUASI-OPTIMUM ZONE (ELECTRONIC VIEWFINDER)
OPTIMUM POINT (OPTICAL VIEWFINDER)
FOCAL ADJUSTMENT

Fig. 7. Curve of picture definition against focal adjustment, showing the limitation on proper camera focusing imposed by an electronic viewfinder.

100 foot-candles for good picture quality, while for outside work Super-Orthicon cameras have been adopted because they will operate with a light intensity of only 5 foot-candles. The first-mentioned types are used, in spite of their great demand for light, because of the more accurate geometrical image reproduction and, in particular, better image gradation. Since the light intensity required in the television studios is about equivalent to that in film studios the performers are quite used to it. With outside broadcasts, however, the picture quality has to take second place to the need for ensuring a transmission of some kind even when the light is very bad. In this work special camera objectives are used which permit a wide variety of viewing angles to be selected, and also vari-optics (made in Britain!) whose focal length can be varied in the ratio of 1:5.

The Super-Iconoscope camera made in Germany (Fig. 6) is somewhat different from those produced in other countries. The most notable difference is in the use of an optical viewfinder, and in our view this has a great many advantages over the electronic viewfinder. In the first place the image field is somewhat bigger than the transmitted image and consequently is more helpful in picking out the best viewing angle. Next, the focusing of the camera is improved, since with the electronic viewfinder the line structure tends to obscure the point of optimum focus so that one can never be sure when one is on it. This is illustrated by the diagram in Fig. 7. We also consider it an advantage that the camera operator is solely responsible for the viewing angle and the image definition: the responsibility is not shared between him and the technician at the camera amplifier, as with the electronic viewfinder.

Another point is that the brightness of the optical viewfinder picture varies in accordance with the exterior brightness, whereas the constant brightness of the electronic viewfinder picture is too poor in sunlight and too intense in dark rooms. Finally there is the smaller number of component parts in the optical viewfinder, which makes for greater reliability and also a reduction in size and weight. These advantages seem so important to us that we cannot understand why such uncritical preference is given everywhere to the electronic viewfinder. In the author's opinion, the electronic viewfinder is of importance only in cameras equipped with vari-optics.

During the three years that the television service has been running a good many technical improve-

Fig. 8. Control centre at Cologne for Eurovision.

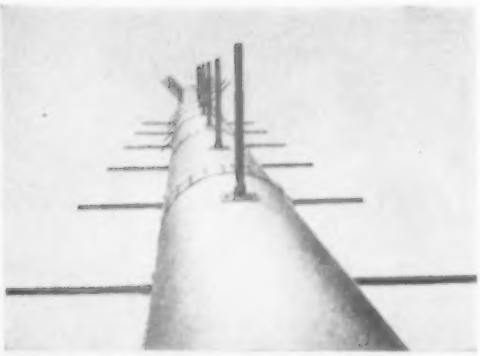


Fig. 9. Combined television and v.h.f. sound aerial of the Teutoburger Wald transmitter.

ments have been introduced. Among these the differential equalizer, which was brought in following the example set by the B.B.C.,* is particularly worth mentioning. Another type of correction has been introduced in the transmitting equipment to compensate for the phase distortion in receivers (to which the picture is very sensitive) caused by the vestigial-sideband and selectivity characteristic of the i.f. response curve. In the television collecting bar system a control centre has been set up at Cologne (Fig. 8) specially for Eurovision programmes, and this contains a standards converter for converting foreign standards into our 625 lines.

*G. G. Gouriet. "Spectrum Equalization." *Wireless Engineer*, May 1953.

Fig. 10. The Stuttgart television and v.h.f. tower. Total height is 690ft while the "crow's nest" is 50ft in diameter

The control centre at Cologne, incidentally, consists of three rooms, one being for technical operations and another for programme arrangements, while the third is a studio for making announcements and giving commentaries. The technical operations room is equipped with a picture switching desk handling all the necessary inputs and outputs, mixing desks for vision and sound, and 20 television sound and control lines with the appropriate telephone and switching devices. There are also two 35-mm film scanners, a slide scanner, monitoring and test equipments, a teleprinter and a spare power supply. On some occasions this control centre has taken over the job of the Eurovision co-ordination centre at Lille when this has been necessary for technical or staffing reasons.

Coming now to the transmitters, most readers will probably be aware that the majority of German television transmitters operate in Band III in the region of 200 Mc/s. There are, however, a few stations operating in Band I. Fig. 1 shows the present transmitters and their service areas and also includes the transmitters which are expected to be in operation by the end of the year (with their estimated service areas). The other transmitters, shown without service areas and not linked to the "collecting bar," will not be ready for some time yet. At present some 70 per cent of the population live in districts where good reception is obtainable. When the extension planned for the end of 1956 is completed about 80 per cent of the population will be provided for. A further extension will be necessary to fill in the last few blank spaces on the map, and it is likely that a new frequency band near 500 Mc/s will be used for this, as well as for a possible alternative programme.

Incidentally, it proved to be a great advantage in the construction of the television stations that the transmitting technique, network planning, choice of sites and use of aerial masts could be coupled with the v.h.f. sound broadcasting network completed only a short while beforehand. Fig. 9 gives an example of this, showing how the aerials for television and v.h.f. sound are combined into one.

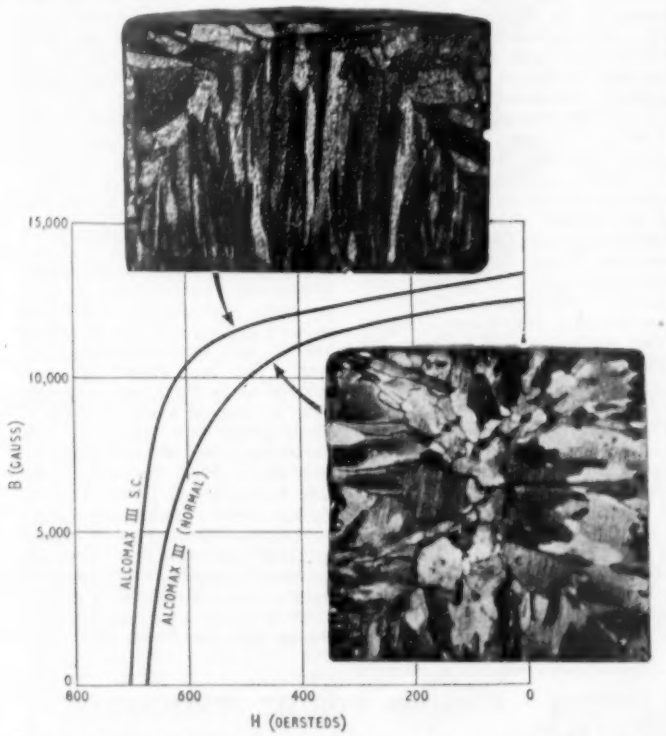
From the point of view of mechanical design the Stuttgart station near Degerloch is particularly interesting. It is a tall tower 530ft high (see Fig. 10) with a four-storey "crow's nest" on top which contains the transmitters and a restaurant, surmounted by the 160-ft lattice aerial mast.

At the receiving end, the development of the last three years has resulted in a considerable reduction in receiver prices because of the increasing number of sets manufactured. At the same time the average size of screen has increased from the 14 inches diagonal originally preferred to 17 inches, while quite a large number of receivers even have screens of 21 inches. Projection receivers for hotels giving 3ft-wide pictures and for cinemas giving 13ft pictures are also on sale. On the occasion of the German Radio Show at Dusseldorf in 1955 the industry showed what it could do, while the public demonstrated its increasing interest in television. At present some 290,000 receivers are in operation—and this does not include all the sets for which no licences have been taken out. In a few years' time we have every hope that the number of viewers will reach the 5 million mark as in Great Britain at the moment. At any rate, television techniques in Germany are prepared for it, at both the transmitting end and the receiving end.

NEW MAGNETIC MATERIALS

A RANGE of permanent magnet materials having properties intermediate between Alcomax and Columax has been introduced by the Permanent Magnet Association. It will be remembered that Columax is an alloy which has a columnar crystalline structure and the highest performance of any known p.m. material; but it is difficult to produce economically in large quantities.

The new materials, Alcomax S.C., are semi-columnar and can be produced in short cylindrical shapes from $\frac{1}{4}$in diameter upwards for use in loudspeaker magnets.



Typical magnetization curves for normal Alcomax III and Alcomax III S.C., together with etched sections showing their crystalline structure.

FARADAY CIRCUS?

ALTHOUGH there are memorials to Michael Faraday at the Royal Institution, the I.E.E. and in Westminster Abbey, there is no memorial to him in the Borough of Southwark where he was born. With the redevelopment of the area including Newington Butts—his birthplace—it is proposed to name an important road junction nearby after him and to erect a memorial. A committee of representatives of various institutions, including the I.E.E., the Faraday Society and the Royal Institution, has therefore been set up to investigate the most desirable kind of memorial to be erected.

It can perhaps be claimed on Faraday's behalf that he propounded the fundamental principle of radio. In a letter, deposited at the Royal Society in 1832 "to take possession as it were of a certain date" should his views be confirmed by experiments, he wrote "Certain of the results of the investigations . . . lead me to believe that magnetic action is progressive, and requires time; i.e., that when a magnet acts upon a distant magnet or piece of iron, the influencing cause (which I may for the moment call magnetism) proceeds gradually from the magnetic bodies, and requires time for its transmission which will probably be found to be very sensible. I think also, that I see reason for supposing that electric induction (or tension) is also performed in a similar progressive way. . . ."

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RANDOM RADIATIONS

By "DIALLIST"

Ally Pally

IT'S HARD to realize that it's twenty years all but a few months since the Alexandra Palace station started the world's first high-definition television service. But twenty years it will be, come November. Old hands (and even some of the not-so-old ones) may recall that it began with two rival systems on trial. One was the Baird with sequential scanning and the other the Marconi-E.M.I. using line interlace. Each concern installed its own transmitter and for some little time they were used alternately for periods of a week. There wasn't then any Sunday television. Eventually, the interlaced scan was found to give the better and less flickery picture and sequential scanning dropped out. Note that I wrote "the first high-definition television service." The first television transmissions were actually made a good few years before that on London's 9-kc/s sound broadcasting channel by means of the original Baird 30-line scanning-disc system. The real image was quite tiny, but a lens increased its apparent size to something like that of a quarter-plate photograph.

A Good Start

The London television station is outside my receiving range now; but from what one hears the new station at the Crystal Palace seems to be fulfilling expectations, to say the least of it. Many with older double-sideband receivers who didn't expect to get an acceptable picture are more than satisfied with the results. Naturally, it'll take a bit of time to get things sorted out: lots of viewers, for example, probably forgot to have their aerials reoriented. The fact that the coverage is so good with a "jury" mast and an e.r.p. of only 60 kilowatts shows that wonderful results should be obtained when the permanent 640-foot tower comes into use within the next 12-18 months and the e.r.p. eventually goes up to 200 kilowatts.

Electronics on Show

HOW MANY exhibitions are there each year in London alone in which radio and kindred electronic gear are shown? Besides the National Radio Show, I can think right away of the R.E.C.M.F. Exhibition, the Television Society's, the Physical Society's, the S.B.A.C. (Farnborough), the Ideal Home, B.I.F., Electrical Engineers' Exhibition, the Motor Show and the Marine and Shipping Exhibition. And there are probably several more. It does seem an awful lot when you come to think of it; but I suppose it's worth while to have so many. At some of them, of course, specialized forms of apparatus are on view: aircraft radio at the S.B.A.C. show, marine radar and communication equipment at the Shipping Exhibition, and so on. Exhibitions are some of the manufacturers' best shop windows, for they attract so many potential buyers from abroad as well as from this country.

Clearing Band III

THE allocation of Channel 10 to the Yorkshire I.T.A. transmitter on Emley Moor shows that some progress is being made in the clearing of Band III for television. The P.M.G. has told us that he hopes to have two more Band III channels (making five in all) free reasonably soon. But the authorities concerned will really have to get a move on if they're really anxious for I.T.A. to expand as rapidly as possible. I.T.A.'s plans include at least two stations to be opened during next year. These are Scotland and South Wales. Both the Authority and the dealers and viewers in the districts concerned need to know which channels will be assigned to particular areas so that they can plan accordingly. And it's *rather* important that those who manufacture aerials should know what channels they have to cater for.

Suppressors That Don't

MOTOR VEHICLE ignition interference doesn't seem to me to show any signs of decreasing; in fact, I'm inclined to think that it's becoming heavier and more annoying than ever. The law obliges all new vehicles to be fitted with suppressors; yet a good many of those of quite recent date cover the TV screen with lines of interference as they pass. Have the suppressors been removed? Or aren't they of the right kind? Ineffective suppressors are sometimes fitted by manufacturers to various domestic electrical appliances. It's rather a shock to the purchaser of a gadget, which is stated to be suppressed, to receive, soon after he (or more often

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she) starts to use it, a visit from someone suggesting that they are causing quite a bit of interference. The wise person does not buy such things without first insisting on a demonstration to prove that they don't cause interference.

Adaptors and Convertors

The P.O. is showing signs of getting tougher in the matter of interference with television reception from sets which were either unsuitable for conversion, or have been fitted with unsuitable Band III adaptors or convertors. In some areas, at any rate, people have been told that they'll be for it if they continue to use such sets for Band III reception. Dealers should, I feel, be more cautious about carrying out adaptation jobs. It doesn't do them much good to have customers who, after spending a tidy sum on having their sets adapted, find that they can't switch on the I.T.A. programmes without arousing the wrath of their neighbours.

Radar Progress

WHAT enormous strides radar has made since it was first developed by the "back-room boys" of Bawdsey and christened R.D.F. The first Army equipment, GL1, could measure only range and bearing and it wasn't at all an easy thing to use. The Bedford attachment for measuring the angle of elevation (and so enabling the height of an aircraft to be found) wasn't in anything like general use until about a year after the start of the war. Then came GL2, which was a vastly better outfit, though it had the drawback of containing far too many mechanical bits and pieces—gear trains and suchlike—in its innards. Both of these GLs were metre-wave equipment; but GL3 and its successors used the then newly developed cavity magnetron and wavelengths dropped to the centimetre region. Automatic following was the next big advance and that has now been brought to such perfection that, once you've selected your target, you just lock the instrument on to it and it does the rest. Some years ago Sir Edward Appleton suggested that one day we might have what he termed "radar - television": you wouldn't just see a "blip" on the screen; you'd see the target ship or 'plane so clearly that you could identify it. Marine radar can already give such clear pictures of coastlines, harbours and so on that we've gone quite a way towards radar-television.

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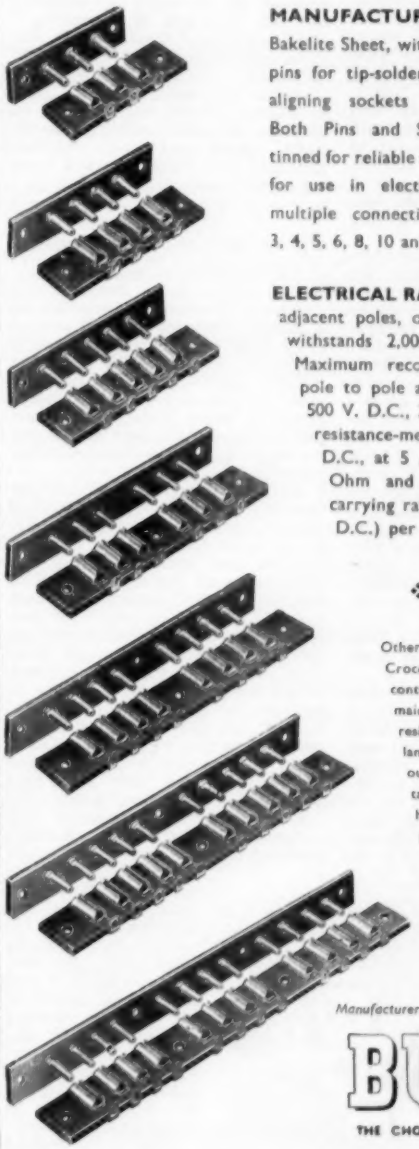

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Presbyotic Problems

IT IS an astonishing thing how few cinemas provide special phone-fitted seats for people who are hard of hearing. One manager with whom I raised the question said they were not needed now that good hearing aids are available through the N.H.S. I could not agree less. My own hearing is far from 100 per cent and I have often compared listening to B.B.C. programmes with a conventional hearing aid and with a pair of earpieces coupled direct to the output of the set. The latter is very much the better.

In fact, the use of a modern hearing aid which is excellent for ordinary conversational purposes does not give me such good results as does an old-fashioned ear trumpet directed at the loudspeaker. Perhaps some of you acoustics experts can tell me why. The result is that when Mrs. Free Grid and I go to a friend's house in the evening I invariably take my ear trumpet with me in case we are invited to look at or listen to some special programme.

My ear trumpet naturally excites ridicule and jokes about approaching senility which are not made when an electrical hearing aid is used. As for signs of approaching senility, surely everything in life is that, including the cutting of a baby's teeth and the growing of its hair which do not happen until it has moved a little along the road from the cradle to the grave.

I think the loss of fidelity, when listening to a loudspeaker with a hearing aid stuck in front of it, arises because the signals, having just been converted from electrical to acoustic energy, have once more to be re-converted to electrical impulses by the hearing-aid mike and then again turned into acoustic ones by the earpiece. This extra conversion is the last straw which breaks the camel's back.

I have successfully solved the problem in my home by adopting the new technique of concealing a metal conductor fixed around the room and using a pair of induction earphones. Surely cinemas and churches too should be fitted with a conductor fitted on the backs of all seats. In many buildings having nasty echoes and poor acoustics generally, even those of normal hearing would welcome this.

Transistorized Telearchics

I AM interested to hear that a record changer is to be marketed which can be remotely controlled by a transistor transmitter small enough to be held in the hand. The firm responsible for this is also to market a radio gram—not to be confused with an ordinary one-word radiogram—in which there is a wireless link between the record player and the amplifier. Maybe the two instruments will be combined.

Basically the two ideas are not new, but this practical application of them in modern form most certainly is. I would have liked to buy one of these new instruments—but one thing deters me and that is this. The range of the small transmitter is said to be 25 *yards*. But only a few *feet* separate me from my neighbour on the other side of the party wall. Thus if he objected to my playing Sousa in full blast he would only have to buy one of these new instruments himself and use its transmitter to turn off my record player. In fact it could develop into a duel of rapid fire between our two pistol-grip miniature transmitters; in-out, in-out, like a French government.

Worse than that, the transmission from my radio record player would pass through the party wall and could be used to operate the amplifier part of his instrument. Thus he could just sit back with a tankard of beer and enjoy himself at my expense, leaving me to shoulder the cost of constantly getting new records; with L.P. ones at 35s apiece he would save no mean sum of money.

Even if the makers arrange that instruments sold to neighbours be adjusted to slightly different frequencies, as I expect they will, my own neighbour could easily find out my frequency and adjust his instruments accordingly. I can see no solution save the unæsthetic one of lining my walls, ceiling and floor with earthed wire-netting and I hope the manufacturers will supply a roll of it with each instrument they sell.

My ear trumpet excites ridicule.

Three Minutes' Silence

WHILE at the B.I.F. I noticed among the exhibits of Smith's, the well-known firm of clock makers, one of those timepieces with specially marked dials for use in ships' wireless cabins. They have two red segments which at their circumferential end extend from the 15th to 18th and the 45th to 48th minutes after the hour, respectively.

Radio officer's timepiece.

These are the periods when ships' transmitters are intended to keep silence in order to enable a careful look-out—or more correctly, listen-in—to be kept for distress signals and the red segments are to remind the operator to stop transmitting.

One of the firm's representatives on the stand, noticing my interest in these clocks, told me in very sarcastic tones that the red segments were really only ornamental as few operators at sea bothered to observe these periods of silence. I have heard this criticism before, but, while there are undoubtedly some black sheep afloat, I don't think that the non-observance of this silence is entirely the operators' fault.

At a time when operators are busy handling heavy traffic surely it is all too easy for them to overlook the approach of the 15th and the 45th minute of each hour. Surely the fault lies with higher authority who should call upon the clock manufacturers to do something better than paint these clock faces like those of Mrs. Free Grid and her friends when going out for an evening.

The proper remedy is to fit the clocks with simple electrical contacts so that a warning signal could be injected into the operator's earphones. This, I feel sure, would make all the difference in the world and would really result in a deep and dramatic three minutes' silence at sea every half-hour, as is intended by the international regulations.

TRADITION

IN A YOUNG INDUSTRY

The oldest high fidelity amplifiers in the world are of LEAK manufacture. In 1945 as the result of war-time research in our laboratory we were able to offer, to an astonished world of audio engineers, amplifiers with a distortion content as low as 0.1%. A survey of engineering literature will confirm that we were the first manufacturers in the world to design and market amplifiers with such a small distortion content, and the magnitude of this advance can be gauged when it is remembered that the then accepted standard for laboratory amplifiers was 2% distortion. Our figure of 0.1% was received with incredulity, but it was subsequently confirmed by the National Physical Laboratory and this criterion is still an accepted world-wide standard.

With this clear lead on low-distortion amplifiers we were able to build up an export market much greater than the domestic one, and the increased volume of manufacture resulted in lower prices, which, in turn, brought real high fidelity amplifiers within the reach of the music-lover at home.

We have devoted 21 years entirely to the development and manufacture of audio products and we are proud of our position as the leaders in this field. We are also proud of the fact that the "Point One" amplifiers supplied to our first customers are still giving them results which, even now, cannot be surpassed. Our research and development departments are ever active, our pre-amplifiers have been redesigned for use with the latest input devices, and we have made great progress in the war on prices. From long experience, by the employment of new techniques and by extreme attention to design details during development work on the pre-production models, we enable our labour force to achieve a high output per man-hour. The labour costs thus saved offset the increased costs incurred for high-grade materials, components and finishes, and this together with quantity production (made possible only by a world-wide market) explains how quality products may be sold at reasonable prices.

To our old customers we give our thanks for their support and recommendation—the basis on which our Company has grown. Those who are seeking to obtain the highest quality of gramophone and radio reproduction would be wise to hear and inspect LEAK products which, with their tradition of excellence, represent the best that can be obtained; used by the B.B.C. and overseas broadcasting companies and recording studios throughout the world.

LEAK
HIGH FIDELITY EQUIPMENT

LEAK TL/10 AMPLIFIER & 'POINT ONE' PRE-AMPLIFIER

27 gns. *complete*

POWER AMPLIFIER

Circuitry
A triple loop feedback circuit based on the famous TL/12. The output transformer is the same size as in the TL/12

Maximum power output: 10 watts.
Frequency Response: ± 1 db 20/cs to 20,000 c/s.
Harmonic Distortion: 0.1%, 1 000 c/s, 7.5 watts output.
Feedback Magnitude: 26 db, main loop.
Damping Factor: 25.
Hum: —80 db referred to 10 watts.
Loudspeaker Impedances: 16 ohms, 8 ohms, and 4 ohms.

The products we manufacture are:
Amplifiers
Dynamic (Moving-Coil) Pickups
F.M. Tuner Units
and later in 1956 a loudspeaker system incorporating a balanced push-pull electrostatic treble loudspeaker unit.

"POINT ONE" PRE-AMPLIFIER

The handsome gold escutcheon plate contributes to the elegant appearance and blends with all woods

★ **Pickup**
The pre-amplifier will operate from any pickup generally available in the world. A continuously variable input attenuator at the rear of the pre-amplifier permits the instantaneous use of crystal, moving-iron and moving-coil pickups.

★ **Radio**
The radio input sockets at the rear permit the connection of the LEAK V.S. tuner unit. An input attenuator is fitted. H.T. and filament supplies are available from the pre-amplifier.

★ **Distortion**
Of the order of 0.1%.

★ **Hum**
Negligible, due to the use of recently developed valves and special techniques

★ **Input selector**
Radio, tape, records; any and all records can be accurately equalised.

★ **Treble**
Continuously variable + 9 db to —15 db at 10,000 c/s

★ **Bass**
Continuously variable + 12 db to —13 db at 40 c/s.

★ **Volume Control and Switch**
The switch controls the power supply to the TL/10 power amplifiers

★ **Tape Recording Jacks**
An exclusive feature. Readily accessible jacks are provided on the front panel for instantaneous use with Tape Recorders which have built-in (low level) amplifiers.

ELECTROSTATIC LOUDSPEAKERS

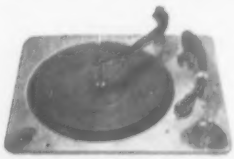
Reprints of "The Gramophone" article (May, 1955), by H. J. Leak, summarising his work and findings on Electrostatic and Dynamic Loudspeakers, are available on request, free of charge.

★ *Write for leaflet W* ★

H. J. LEAK & CO. LTD., BRUNEL ROAD, WESTWAY FACTORY ESTATE, ACTON, W.3

Phone : SHEpherds Bush 1173/4/5 *Telegrams : Sinusoidal, Ealux, London* *Cables : Sinusoidal, London*

G

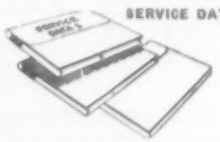


GRAMOPHONE AUTO-CHANGER

Latest types by all famous makers are invariably in stock at competitive prices. B.S.R., Monarch, Garrard, etc. Latest models from **£7/19/6**, plus 5/- carriage and insurance.

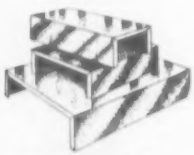
F.M. TUNER

This tuner is based upon the very successful circuit in the booklet published by Data Publications. We have made up models at all branches and will be glad to demonstrate. Cost of all parts including valves, prepared metal chassis, wound coils **and** stove enamelled scale, slow motion drive, pointer, **tuning** knob, in fact everything needed to make **the complete** unit, is **£6/12/6**. Data is included free with the parts or is available separately price **2/-**.



SERVICE DATA

100 service sheets, covering British receivers which have been sold in big quantities, and which every service engineer is ultimately bound to meet. The following makes are included: Aerodyne, Alba, Bush, Cossor, Ekco, Ever-Ready, **Ferguson**, Ferranti, G.E.C., H.M.V., Kolster-Brandes, Lissen, McMichael, Marconi, Mullard, Murphy, Philco, Philips, Pye, Ultra. Undoubtedly a mine of information invaluable to all who earn their living from radio servicing. Price **£1** for the complete folder. **Our Folder No. 2** consists of 100 **data sheets** covering most of the popular American T.R.F. and superhet receivers, "all dry," etc., which have been imported into this country. Names include Sparton, Emmerson, Admiral, Crossley, R.C.A., Victor, etc. Each sheet gives circuit diagrams and component values, alignment procedure, etc., etc. Price for the folder of 100 sheets is **£1**. Post free.



BLANK CHASSIS

18 S.W.G. Aluminium

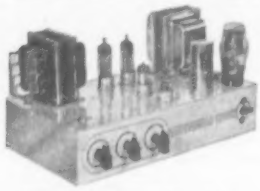
7 × 3½ × 2	3/9	14 × 10 × 3	7/9
9½ × 4½ × 2½	5/-	16 × 10 × 3	8/3
10 × 8 × 2½	5/6	16 × 12 × 3	8/8
10 × 5½ × 2½	5/-	19½ × 9 × 2½	8/3
12 × 9 × 2½	7/-	20 × 10 × 3	10/-
14 × 9 × 2½	7/6		

DASHPOT DELAYED CONTACTOR

American make type No. R.01D. This has adjustment to delay opening and closing, and has secondary contacts suitable for heavy currents operating coil 110 v., 50 cycles. Price **37/6**.

VACUUM RELAY

American made type No. C.61610, this is a relay completely sealed in a glass envelope. It will close in a strong magnetic field or by a coil placed close to or round one of its arms. Price **49/6**. Operating coils 25/- each.



MULLARD AMPLIFIER "510"

A High Quality Amplifier designed by Mullard engineers. Robust high fidelity with a power output exceeding 10 watts and a harmonic distortion less than .4% at 10 watts. Its frequency response is extremely wide and level being almost flat from 10 to 20,000 C.P.S.—three controls are provided and the whole unit is very suitable for use with the Collaro Studio and most other good pick-ups. The price of the unit completely made up and ready to work is **£12/10/-**, plus 10/- carriage and insurance. Alternatively, if you wish to make up the unit yourself we shall be glad to supply the components separately. Send for the Mullard amplifier shopping list.

BAND III CONVERTER

ADDITA—Many hundreds in use

Any television receiver, whether superhet or straight A.C. or A.C./D.C., home constructed or factory built, which at present will receive B.B.C. will also receive I.T.A., if this converter is added. No modifications at all are necessary to the receiver. Simply plug in the aerial leads and connect to A.C. mains. The converter is in a neat metal case with provision for fixing to the side or the back of the set. Price **£6/10/-**, or H.P. terms available on request if required.

BUILD YOUR OWN CONVERTER

You can save at least £3 on the above if you build the converter yourself. Price of all components including stove enamelled case and even transfer for the front is **£3/10/-** or **£4/10/-** if mains components also required. Data is included free with the parts or available separately price **2/6**.

BAND III FILTERS

To eliminate patterning and other interferences. Two models—one high-pass cuts out frequencies above 45 m/c., the other low-pass cuts out frequencies below. Price **27/6** each, postage 2/6.

RECORD PLAYER FOR £4/10/-.

3-SPEED INDUCTION MOTOR

3-speed motor with metal turntable and rubber mat. Latest rim drive with speed selection by knob at the side.

HI-FI PICK-UP

Using famous Cosmocord Hi-G turnover crystal. Separate sapphire for each speed. Neat bakelite case with simple adjuster for weight compensation.

SPECIAL SNIP OFFER THIS MONTH

The two units for **£4/10/-**, or 30/- deposit and four payments of **18/-**, post and insurance, 5/-. **Or fitted upon base, as illustrated, £5/10/-**, plus 7/6 post and insurance.

LIGHTING SNIP

New perfect fluorescent tubes by famous maker—5 feet 80 watt standard B.C. fitting, **9/6**; 4 feet 40 watt standard two-pin fitting, **8/6**. Post and insurance and carriage 1/- per tube. Minimum quantity dispatched 1 doz.

CABINETS FOR ALL

WE CARRY A VERY VARIED STOCK PLEASE CALL

The one illustrated is the "Empress," it is undoubtedly a beautiful piece of furniture. It is elegantly veneered externally in figured walnut, internally in white sycamore. The **radio section** is raised to convenient level but is not drilled or cut. The lower deck acts as the motor board, again is uncut, it measures 16 × 14 and has a clearance of 5in. from the lid. There is a compartment for the storage of recordings. Overall dimensions of this **essentially** modern **cabinet are** 3ft. wide, 2ft. 6in. high and 1ft. 4in. deep. Price **£14/14/-** carriage and insurance 20/-.

TOWARDS AUTOMATION

Rotary **switch**—Ministry Ref. No. AF57879, this is a motor driven **switch**, the driving motor being a synchronous type for working on 110 volts 50 cycles. The two switches have 20 positions each and are enclosed by a Perspex fronted lid. Separately operated relays providing interlocks. Price **£4/17/6** each.

10 AMP ROTARY SWITCHES

A very robust switch, made by one of our most famous firms. Will give lifetime of service. Price complete with pointer knob. 4 pole change over, **10/-**, 6 pole change over, **17/6**. D.P. on/off 15 amp., **4/6**.

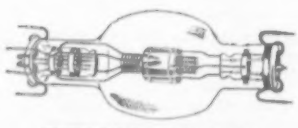
HIGH WATTAGE LAMPS

All G.E.S. Base

1,000 watt, 230 v., **7/6**. 1,500 watt, 230 v., **9/6**. 400 watt (fluorescent), **17/6**.

THE "CRISPIAN" BATTERY PORTABLE

A 4-valve **truly** portable battery **set with** very many good features as follows:—
Ferrite rod aerials.
Low consumption valves.
Superhet circuit with A.V.C.
Ready built and aligned chassis if required.
Beautiful two-tone cabinet covered with I.C.I. Rexine and Tygan.
Guaranteed results on long and medium waves anywhere.
All parts, including speaker and cabinet, are available separately or if all ordered together the price is **£7/15/-** complete, ready built chassis 30/- extra. Instruction booklet free with **parts** or available separately price **1/6**.



TETRODE TYPE VT31

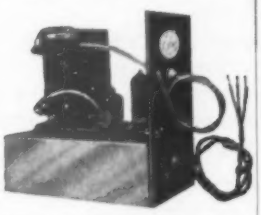
This is a high-powered air-cooled tetrode. Specification of which is as follows:—Heater volts 11.25, heater current 5 amp., maximum anode voltage 5 kV., anode dissipation 250 watts, size approximately 14in. long and 6in. across the bulb.

Limited quantity only at **£4** each, still in original packing. Carriage and insurance, 10/-.

THIS IS ON OFFER AT APPROX. HALF COST TO MAKE

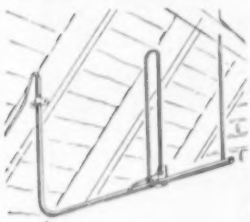
An impressive costly looking cabinet originally designed for T.V. but simple modification makes the cabinet suitable for radiogram, amplifier, tape recorder, or reflex speaker—size 23in. wide, 22in. deep and 37½in. high. Limited quantity at £8/15/- each, carriage 12/6.

E.H.T. GENERATOR



This is a made-up unit, power consumption (6.3 volt 8 amp. filament and approx. 50 mA. H.T.). Contains three EY51 valves. Output from 6 kV to 9 kV rectified with normal H.T. rail input but somewhat higher outputs can be obtained with higher H.T. supply. Dimensions are 6½ × 4½ × 7in. Price 69/6, post, packing, etc., 5/-.

BAND III AERIALS



This is a ½ wave-length, 3 element array. Of all alloy construction, the aerial is completely assembled and ready for instant mounting in loft, bedroom cupboard, window frame, etc. Price 12/6, plus 2/-.

3 element array with swan-neck mast with "U" bolt clamp for fitting to existing masts from ½in. to 2in. dia. 41/6

3 element array with cranked mast and wall mounting bracket 42/6

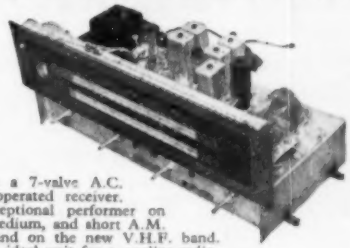
3 element array with cranked mast and chimney lashing equipment ... 65/-

5 element array with swan-neck mast and "U" bolt clamp for fitting existing mast from ½in. to 2in. dia. 52/6

5 element array with cranked mast and chimney lashing equipment ... 67/-

8 element array with swan-neck mast and "U" bolt clamp for fitting to ½in. to 2in. dia. mast ... 69/-

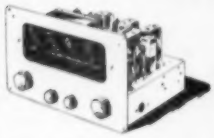
AM/FM RADIOGRAM CHASSIS



This is a 7-valve A.C. mains operated receiver.
An exceptional performer on long, medium, and short A.M. bands and on the new V.H.F. band. It is an ideal unit for a quality radiogram.
Special features include magic eye tuning indicator, extra long scale and pointer travel—latest circuitry employing full A.V.C. feedback, etc., etc.
Undoubtedly one of the finest AM/FM chassis available today.
Chassis size 17½in. × 6½in. × 7½in. Price £23/17/6, carriage, packing, and insurance 20/- extra.

THE ARGONAUT

The Argonaut, a very efficient medium wave and V.H.F. A.C. operated receiver described in the March and April issues of "Radio Constructor," all parts are available and total cost is only £14/10/- which includes drilled metal chassis, nine valves—one of which is a magic eye tuner of the latest type, every resistor and condenser, and even nuts and bolts, etc., needed to completely build the receiver. A cabinet will be available later in the year. The speaker not included in the above is available if required. All parts available separately, send for shopping list.

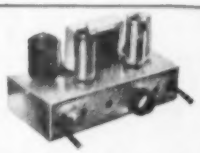


THIS MONTH'S SNIP

14in. T.V. cabinet of the latest styling made for one of our most famous firms—beautifully veneered and polished—limited quantity—19/6 each. Carriage and packing 3/6 extra.

The "ESTRONIC" BAND III CONVERTER

To-day's best value in Band III converters suitable for your T.V. or money refunded Complete ready to operate. 59/6 non mains or 85/- mains, post and insurance, 2/6.



HALF-PRICE OFFER

BEETHOVEN CHASSIS

Extremely well built on chassis size approx. 9½ × 7½ × 8½, using only first-class components, fully aligned and tested, 110-240 volt A.C. mains operation. Three wave bands covering medium and two shorts. Complete with five valves, frequency changer, double diode triode, pentode output and full wave rectifier. Special cash-with-order price this month, £5/19/6, carriage and insurance 7/6. Polished cabinet, 49/6.

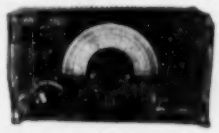
NEW CIRCUIT

OCCASIONAL 56—we have evolved a new T.R.F. circuit and have had really good results, equal in fact to many superhets. You really should try this circuit. All parts including valves (6K7, 6J7, 6P6, and 6X5) and Bakelite case with back cost only £5/10/-, plus 2/6 post and insurance. Data included with the parts is also available separately, price 2/-.

PLEASE INCLUDE POSTAGE WHEN ORDERING

R1155 YOURS FOR £3

and 12 monthly payments of 11/6



The R1155 is considered to be one of the finest communication receivers available to-day. Its frequency range is 75 kc/s. to 18 Mc/s. It is complete with 10 valves and is fitted in a black metal case. Made for the R.A.F. so obviously a robust receiver which will give years of service. Completely overhauled and guaranteed in perfect working order. Price £8/19/6, or £3 deposit, balance by 12 monthly payments of 11/6. Carriage and Transit case 15/- extra. **Mains Power Pack**, with built-in speaker, £5/10/-, or in polished cabinet, £6/15/-.

OFFICE TELEPHONES

New G.P.O. telephone sets with internal bell and push button switch easily connected together to form office intercom. Price £2/10/- each. Post, etc., 2/6.

TRANSFORMER SNIP

11/6

Post 2/-.

Fully shrouded—standard 200-250 v. primary 280-0-280 at 80 mA., 6.3 v. at 3 amp., 5 v. at 2 amp.

FINE TUNERS

Ceramic trimmers all with ¼in. spindles of fair length. 8, 10, 15, 30, F.F. at 9/3 each or 24/- per dozen.

CIRCUIT DETAILS

Diagrams and other information extracted from official manuals. All 1/6 per copy, 12 for 15/-.

American Service Sheets	R.109
A.1134	76 receiver
BC.348	R28/ARC5
BC.312	R1116/A
R.103A	RA-1B
B.C.342	AR88D
RA-1B	AN/APA-1
R-208	78
R-1186	76
R-1194A	R.T.18
R-1179A/R-1481	CAY-46-AAM-RADAR
R-1147	A.S.B.-3
R-1294A	Indicator 62A
R-1099	Indicator A.S.B.3
R-1355	Indicator 62
B.C.1206-A/B	Indicator 6K
B-455-A (or -B)	R.F. unit 24
B-454-A (or -B)	R.F. unit 26
B-453-A (or -B)	R.F. unit 25
Transmitter T1154/R.D.J.N.	R.F. unit 27
Fifty-eight walkie-talkie	Wireless set No. 19
Frequency meter B.C. 221	Demobbed valves

ELECTRONIC PRECISION EQUIPMENT LTD.

249 Kilburn High Road, Kilburn.
Phone: MAI 4921
Half-day Thursday

42-46, Windmill Hill, Ruislip, Middlesex.
Phone: RUISLIP 5780
Half-day Wednesday

152-153 Fleet St., E.C.4.
Phone: FLEET 2833
Half-day Saturday

29 Stroud Green Road, Finsbury Park, N.4.
Phone: ARCHWAY 1049
Half-day Thursday.

Post orders should be addressed to E.P.E. LTD., M.O. Dept. 2, 123, TERMINUS ROAD, EASTBOURNE.
All enquiries to Eastbourne address and please enclose S.A.E., terms are cash with order.

Quality Electronic Equipment. All guaranteed to be in perfect condition

MULTIMETERS

AVO Minor	£7 0 0
AVO 40	£10 0 0
AVO 7	£15 0 0
FERRANTI	£4 17 6
STARK	£5 5 0
TAYLOR 70	£8 0 0
TAYLOR 82	£9 0 0

VALVE VOLTMETERS

AIRMEC	£45 0 0
AVO	£25 0 0
MARCONI	£25 0 0
RCA	£18 0 0
TAYLOR 170A	£20 0 0
TAYLOR 171A	£23 0 0

OSCILLOSCOPES

BROWNING	£16 0 0
COSSOR (D.B.)	£35 0 0
COSSOR (S.B.)	£12 0 0
MULLARD	£35 0 0
TAYLOR	£23 0 0

FREQUENCY METERS
BC221
In Perfect condition

SIGNAL GENERATORS

AVO Wide Range	£20 0 0
COSSOR Ganging Oscl.	£25 0 0
MARCONI 390G	£35 0 0
MARCONI 517	£35 0 0
TAYLOR 65B	£7 10 0
TAYLOR 66A	£20 0 0

MARCONI CR100
As new £20 0 0

WEE MEGGERS
Evershed and Record
500V £10 10 0
250V £8 0 0

COMMUNICATION RECEIVERS

EDDYSTONE

640	£22 10 0
740	£32 0 0
750	£50 0 0

RCA

AR77	£40 0 0
AR88	£55 0 0

HALLICRAFTERS

S38	£24 0 0
S20	£25 0 0
S20R	£28 0 0
SX24	£35 0 0
SX28	£55 0 0
SX71	£95 0 0

NATIONAL

NC173	£100 0 0
NC57	£40 0 0
HRO	£28 0 0

HAMMARLUND

HQ129	£80 0 0
HQ120	£40 0 0

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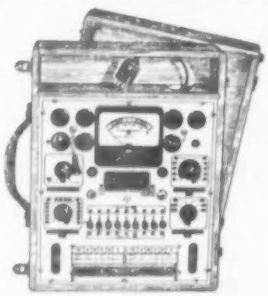

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Let us assist you in its solution. Direct TV Replacements specializes in the production of small batches of replacement transformers. Leading manufacturers have found our service invaluable. Our engineers design a replacement transformer using a Ferox core, or an exact copy of the original, depending upon your requirements. Very often one replacement is designed to cover a number of models, and this simplifies stocking and allows a longer production run.

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Complete with two detachable diamond heads and transformer. **Cash Price £21/19/9** or sent for **£4** Deposit and 10 monthly payments of **40/-**. Post and packing paid.

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HALF TRACK HEADS AVAILABLE:

Model 5RP Record/Play Head	£3 5 0
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Very attractive appearance for panel mounting. *Send for leaflet A.1.*

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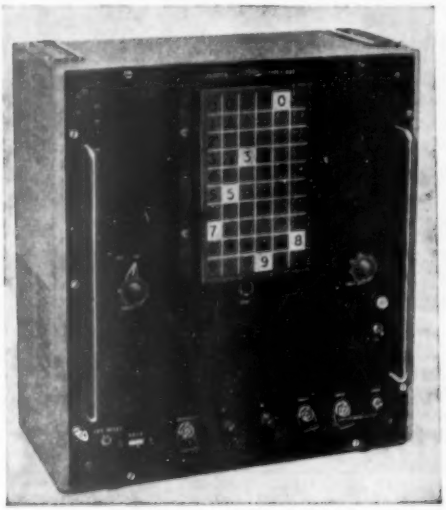
AIRMEC

High-Speed ELECTRONIC COUNTER Type 865



COUNTING SPEED:
Maximum—1 million per second.
Minimum—no lower limit.

COUNTING RANGE:
9,999 million.

COUNT DISPLAY:
Counts up to 999,999 are recorded on a brilliant display employing 6 v. 2 w. lamps behind ¾in. square numbered windows. A four figure electro-mechanical counter extends the range to 9,999 million.

INPUT WAVEFORM:
Sinusoidal or pulse of any waveform, recurrent or random, between 1.5 and 50 v. peak amplitude.

THE COUNTER TYPE 865 operates on electrical inputs of any waveform at speeds up to 1 million per second, and records the total count on a direct reading decimal display of exceptional brilliance and clarity.

Resetting the counter to zero is accomplished either by operation of the reset switch or by externally closing a circuit. Since both gating and resetting operations can be carried out externally, the instrument may be employed in conjunction with suitable auxiliary equipment for making time, speed and frequency measurements.

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PRICE £250

Full details of this or any other Airmec instrument will be forwarded gladly on request

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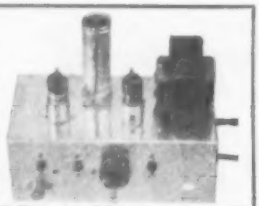
Telephone: High Wycombe 2060. Cables: Airmec, High Wycombe

BAND 3 T.V. CONVERTOR 183/196 Mc/s.



Kit of parts complete to build this most successful unit, comprising drilled chassis, valves, coils, res., cond., etc.; slightly modified version (Wireless World, May, 1954). £9/5/- post free. Send for blueprint and wiring diagram. 1/6 post free. Power Pack Components, including mains transf. and mot. rect., 50/- extra. Provision has been allowed on chassis for Band 1-Band 3 switching. Suitable for most types of T/V sets, T.R.F. or superhet.

B.B.C. BREAK-THROUGH FILTER, tunable filter unit for B.B.C. pattern reception, 8/6.

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5 VALVE SUPERHET. LATEST B.V.A. MIDGET SERIES VALVES

3 WAVEBANDS:—L.W. 800m-2000m, M.W. 200m-550m, S.W. 16m-50m. Chassis size 13½ - 8½ - 2½in. Attractive Glass Dial 10 - 4½in. edge lit by 3 pilot lamps. Horizontal or Vertical Station Names and 4 control knobs, walnut or ivory to choice. 4 position W/C switch, L.M.S. and Gram. P.U. sockets. Modern circuitry, all coils adjustable, dust cored and only quality components used throughout. Delayed A.V.C. and neg. feedback. A.C. mains 200-250 v. Double wound transf. isolates chassis from mains. Aligned and calibrated ready for use.

BRAND NEW & GUARANTEED £9.15.0 Carr. and ins. 4/6.
3-ohm speakers suitable for this chassis available 8" 19/6, 10" 25/-

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Ideal for home or workshop. 4ft., 220-250 v., complete with tube, ballast unit, etc. ready for use. Famous manufacturer's surplus offered at approx. half price. Starter switch type 4/2/-. Quick start type 4/7/6. Carr. and ins., 7/6 extra.

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100/25 v.	2/-	8 + 16/500 v.	5/6
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8+8/500 v.	4/6	16 + 16/450 v.	5/6
8+16/450 v.	5/-	16 + 16/450 v.	6/-
16/350 v.	3/-	32/350 v.	4/-
16/450 v.	3/6	32 + 32/275 v.	4/6
16 + 16/450 v.	5/6	60 + 250 v.	6/6
32/350 v.	4/-	60 + 350 v.	6/6
32/500 v.	5/-	80 + 250/275 v.	12/6
32 + 32/350 v.	5/6	64 + 120/275 v.	11/6
32 + 32/450 v.	6/6	100 + 200/275v.	12/6

80 ohm CABLE — CO-AXIAL

SPECIAL—Semi-air spaced polythene, standard ¼in. diam. Stranded core. Feeder loses not 50%. 9d. yard.
Standard ¼in., Grade A, 6d. yard.
COAX PLUGS 1/2. SOCKETS 1/-.
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BALANCED TWIN FEEDERS per yd., 6d.
Special 300 ohm TWIN FEEDER 8d.
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50 OHM COAX CABLE 8d. per yd., 11in.
ATTENUATERS 6db, 12 db, etc., from 3/6. Band 1-3 Cross-over filter unit from 10/6.

CONDENSERS.—Mica, Silver Mica. All pref. values, 2 pf. to 1,000. 6d. each. Ditto ceramics 9d. each. Tubulars, 450 v. Hunts and T.C.C. .001 mfd.-.01 and .1/350 v., 9d. each. .02-.1/500 v., 1/- each. .25 Hunts, 1/6. .5 Hunts, 1/9.

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JASON F.M. TUNER UNIT 87-105 m/cs

Kit of parts to build this modern and highly successful unit complete with drilled chassis and J.B. dial, wound coils and screening cans, 6 BVA miniature valves and all necessary quality components, etc., for only £6/10/- post free. Superior dial calibrated mc/s, edge lit by 2 pilot lamps, 12/6 extra. Power Pack components kit including double wound mains transformer, £2/5/- extra.
Tested and approved by "Radio Constructor," etc. Illustrated handbook with full details 2/-, post free.

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Wire ends. Silicone coated. 25 ohms-10,000 ohms, 5 w., 1/3. 5 w., 1/9. 10w. 2/3. 10w. 1/6; 15 w., 2/-; 15K-33K.
LINE CORD .3a 60 ohms per ft., .5a 100 ohms per ft., 2 way 6d. per ft., 3 way 7d. per ft.

ALUMINIUM CHASSIS

18 g. Plain undrilled. Folded 4 sides, riveted corners, lattice fixing holes. Depth 2½in., 7 × 4in., 4/6; 9 × 6in., 5/9; 11 × 7in., 6/9; 13 × 8in., 8/6; 14 × 11in., 10/6, etc.

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E.H.T. types. K3/25 2 Kv., 4/3; K3/90 2.5 Kv., 6/-; K3/45 3.6 kV., 6/6; K3/90 4 kV., 7/3; K3/100 8 kV., 12/6, etc.
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RM4R type, 275 v., 275 mA., 17/6. LT types F.W. bridge 6-12 v. 1½ a., 8/9; 3 a., 15/6; 4 a., 18/6; 6 a., 21/6 each.

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1in. semi Midget type, long spindles. All values 10,000 ohms to 2 Megohms. Less sw., 3/-; S.P. sw., 4/-; D.P. sw., 4/9. All individually boxed. Guar. 12 months.

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DEVELOPMENT ENGINEERS in departments covering the design and construction of a wide range of electronic equipment and high-grade television transmission equipment. Good fundamental knowledge required and some practical commercial experience desirable.

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★ **OPPORTUNITIES FOR PROMOTION**
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MICROPHONES & RECEIVER HEADGEAR

Assy. No. 2 (ZA 2905) consisting of 100 ohms impedance MC headphones, Tannoy high power microphone.

18/- each.

TRANSMITTER/RECEIVER No. 22

2 mc.-8 mc. complete with all valves, power pack for 12 v. D.C., both installed in a carrier, headgear and microphone assembly. All in excellent condition, very economical current consumption. Ideal for mobile use.

Price £11/15/- each. Carriage 20/- extra.

SPARE PARTS FOR AR 88-D. & L.F.

	Each
Mains transformers	£4
Output transformers	30/-
Filter chokes	25/-
I.F. transformers	15/-
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I.F. Crystal transformers	15/-
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Block condenser 13 x 4 mF.	25/6
Band switches	37/6
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Phrasing trimmers	3/6

All the above are fully reconditioned and guaranteed to be in excellent working order.

GOVERNMENT SURPLUS VALVES

A large selection available, please state your requirements.

J. P. ELECTRIC

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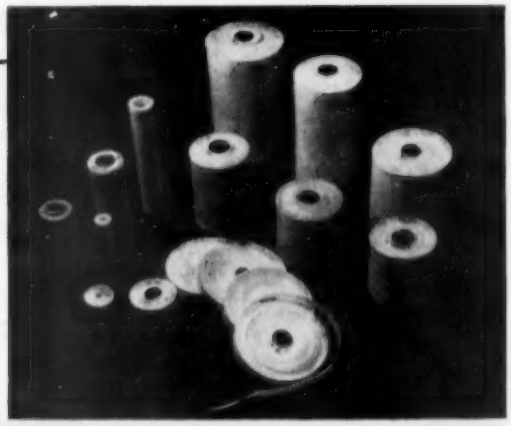

Polytetrafluoroethylene (PTFE)

THIS COMPANY began experimenting with PTFE when it was first introduced into this country. Shortly afterwards we started processing and fabricating the material in a special division of our own factory, giving our own designation of CF2 (derived from the formula) to the range of products ultimately produced.

Since that time, our experience, both of the behaviour of the material itself, during processing, and the application of its remarkable properties has been accumulating.

We have developed techniques, and we have designed special equipment with which to apply them, so that we now mould, fabricate, and otherwise fashion PTFE from its basic forms, i.e. rounds, discs, flat mouldings, rings, cylinders, rods, tubes, tape and cord, as illustrated, into innumerable components which are already widely used by the electrical and electronics industries. We also have considerable experience in the application of PTFE dispersion coatings to a wide variety of materials and surfaces.

It is obviously impossible for a material of this kind to attain its full usefulness to any industry without research and experimental work. We have set aside a substantial part of our resources for this purpose, and will willingly co-operate with any Company desiring to make use of the material, to the fullest extent of these resources. By arrangement we will make available facilities for practical development work to be carried on.

The following Information Bulletins are now available: No. 4, BASIC PROCESSING AND PROPERTIES, and No. 5, APPLICATIONS. *Both of these publications will be sent on request to interested engineers.*

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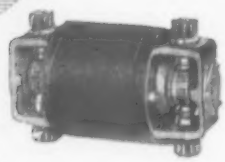

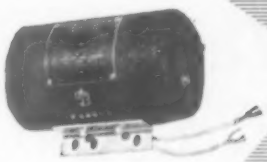

Specifications

- H.T.31. Input 11.5 volts.
- Output 250 volts at 125 m/a.
- Dimensions: Length 5¼in.
- Diameter: 3¼in. inc. brushes.
- Weight: 4¼ lb. Tropicalised if required.

- H.T.30. Dimensions ditto. Input 11.5 volts.
- Output 400 volts at 65 m/a. Tropicalised if required.
- Dynamotors. D.C. Input. 27 volts at 1.75 amps.
- D.C. Output 285 volts at .075 amps.
- The above can also be supplied in 12 volts.

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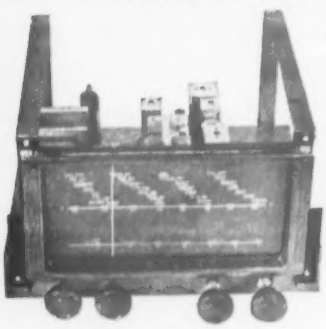

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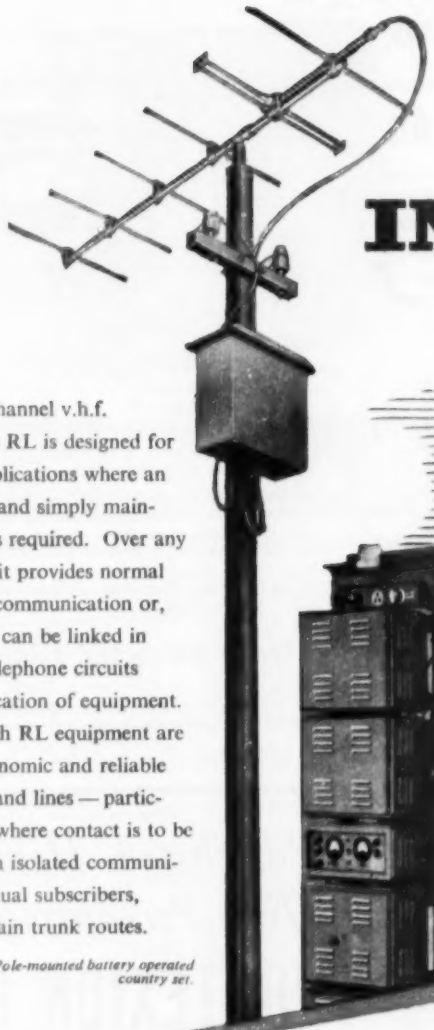

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100 ,,	2½in.	MC/FR	12/6
200 ,,	2½in.	MC/FR	12/6
250 ,,	2½in.	MC/FR	12/6
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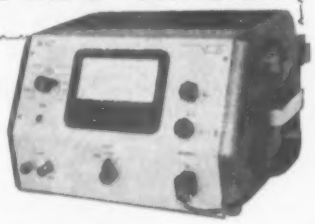

	D.C. Ranges	A.C. Ranges
Volt -	0-300 *mV*	0-1*V*
Ranges -	0-1*V*-0-300*V*	0-3*V*-0-100*V*
Accuracy	±2% of f.s.d.	±2% of f.s.d.
Input -	For the first five ranges, 25 megohms	20 megohms up to medium R.F. on all ranges

On lower D.C. ranges, this instrument approaches conditions of an electrostatic voltmeter and on A.C. ranges a measuring diode contained in an external probe, is provided. To minimize the effect of the metal body of the probe, the insulated terminal head can be replaced by a spike. All-range indicator consists of a 5-inch meter fitted with knife-edge pointer and mirror scale. Send for leaflet giving full specification.

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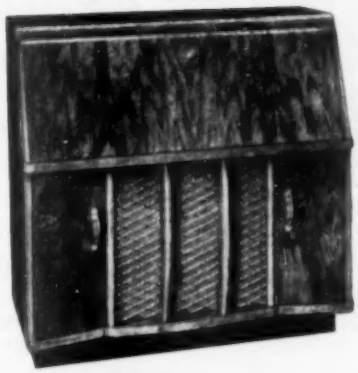

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CAT. NO. CAB/03

A magnificent Bureau type Cabinet of the very highest quality in specially selected Walnut veneered exterior. Light Sycamore interior with Rexine lining to match. Outside dimensions, length 34in., depth 17½in., height 33in. Sloping control panel on right-hand side approx. 16in. x 10½in. Removable baseboard on right side approx. 15½in. x 15in. Two full-sized felt lined compartments in the lower half.

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PACKING AND CARR.: Payable in advance with order—25/-.

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Superhet. Chassis of Latest Design and Technique.

General Specifications applicable to all models.
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Dial: Suitably lit multi-coloured glass dial of the horizontal type.
Tuning Drive: Slow motion by means of glass-cored Nylon cord.
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Cat. No. TR/A

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TAPE DECK: TRUVOX model TR7U. Twin track with B.S.S. sense of recording. Two speeds, 7½in. (one hour for 1,200ft. reel), and 3¾in. (2 hours for 1,200ft. reel). Full press-button control. Fast forward and rewind. Electro-magnetic braking. **44 Gns.**

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Cat. No. TR/A/KIT.

A complete kit consisting of:—
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CAT. NO. FMT/A

An F.M./V.H.F. Tuner Unit with automatic Magic Eye Tuning, fitted in a high grade dark Walnut cabinet. Adaptor is self-powered and completely self contained.

CIRCUIT DETAILS: 81X Valves and 10 Tuned Circuits for maximum sensitivity and best signal to noise ratio.

Packing and Carriage 12/6. **16½ Gns.**

CAT. NO. FMT/B

An F.M./V.H.F. Tuner Unit in chassis form, suitable for building into existing Radiograms or Radio Receivers. Adaptor is self-powered. Socket for additional Magic Eye fitment is provided in the Chassis.

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A Unique Achievement.

These consist of all the necessary components, i.e., Radio Receiver Chassis, Automatic Record Changer and fully matched Loudspeaker, mounted on a light-weight well finished frame with the top panel polished in a medium Walnut shade. In itself it is a fully operative Radiogram and only needs to be fixed inside any suitable Cabinet. Fully assembled, wired and tested at the place of manufacture, it enables the highest grade of Radiograms to be built with absolutely no technical knowledge and at a much lower cost than otherwise obtainable. Offered in two different models.

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RECORD CHANGER: Latest B.S.R. FOUR-SPEED Automatic Record Changer with high fidelity HGP-37 Crystal Turn-over cartridge, suitable and fully matched for all standard and long-playing records.

Packing and Carriage, 20/-. **29 Gns.**

MODEL AND CAT. NO. UNIT/AFM47. Incorporating F.M./V.H.F. Band.
CHASSIS: Similar to Radio Chassis, type CR/AFM47 described elsewhere. SEVEN valves Superheterodyne with F.M. (V.H.F.) band. FOUR Wavebands (Long, medium, short and F.M./V.H.F.), with Magic Eye tuning.
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Packing and Carriage, 20/-. **37½ Gns.**

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Permanent Magnet Type (Voice Coil Impedance 3 ohms)
CAT. NO. LS/10/PM: 10in. diameter, Flux density 8,500 lines.
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CAT. NO. LS/74/PM: Elliptical 7in. x 4in. Flux density 7,500 lines.
PRICE: CASH ONLY £1/1/-.
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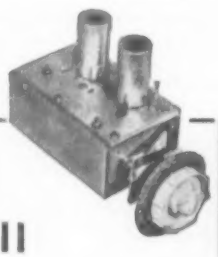
SUPPLIERS OF RADIO COMPONENTS, ELECTROLYTICS, AND CATHODE RAY TUBES.



TUNERS for BAND III

COMMERCIAL TELEVISION

Valradio tuners cover all 13 British Channels, and have been specially developed for incorporating into new T.V. receivers, or for tuning standard receivers to Band III. Available for AC sets using 6·3 parallel connected valves, and AC/DC with ·3 series connected valves. I.F. outputs 9-14 mcs; 16-20 mcs; 19-24 mcs and 34-40 mcs. Price. **£6.0.0**

Ask also for details of Valradio T.V. Projection Receivers; DC/DC and DC/AC Converters; Vibrator Units.

Valradio LIMITED

New Chapel Road, Feltham, Middx. Phone Feltham 4242

"FIREFLASH"

THE FAIREY AVIATION COMPANY LIMITED · WEAPON DIVISION

The team which designed the "Fairey Fireflash", the first guided weapon for the Royal Air Force, must now be expanded at all levels in order to undertake new projects entrusted to it.

If you would like to discuss the immediate advantages and your future career if you join one of the most successful Guided Weapon teams in the country, please write, quoting Ref. GD, to:—

THE FAIREY AVIATION COMPANY LIMITED WEAPON DIVISION, CRANFORD LANE, HESTON, MIDDLESEX

supplying personal details and indicating in what particular type of employment you are interested.

Appointments are immediately available for draughtsmen, technicians, engineers and scientists who have design, development or testing experience in one or more of the following:—

GUIDED WEAPONS; SERVO-MECHANISMS; INSTRUMENTS; AERODYNAMICS; STRESSING; STRUCTURES; AIRCRAFT ELECTRICAL INSTALLATIONS; ELECTRONICS (MICRO-WAVE AND PULSE TECHNIQUES, AERIALS, CIRCUITRY, TRANSISTORS, POWER SUPPLIES, TEST GEAR); FIELD TRIALS.

All appointments offer every opportunity to become familiar with the new techniques associated with this work and rapid progress can be made by those with initiative and ability.

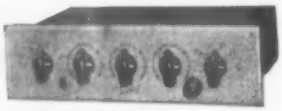
Excellent salaries and bonuses are offered, together with first class working conditions. There is a Pension Scheme incorporating Life Assurance. A large number of varied social and sports activities are available to all those interested. The Company also runs a Flying Club near Maidenhead, where employees can learn to fly at very reduced rates.

STERN'S "fidelity" 10 Watt Main Amplifier

(See brief description on this page.) We offer the COMPLETE KIT OF PARTS to build the MAIN AMPLIFIER for **£11/11/0** (plus 5/- carr. and ins.) or we will supply it COMPLETELY ASSEMBLED for **£13/13/0** (plus 5/- carr. and ins.)

H.P. Terms. Deposit £6/18/- and 8 monthly payments of 19/4. The full SPECIFICATION and BUILDING INSTRUCTIONS are available for 1/6.

STERN'S "fidelity" Pre-Amplifier-Tone Control Unit



The COMPLETE KIT of parts for **£6/6/0** (plus 5/- carr. and ins.) or we will supply it COMPLETELY ASSEMBLED for **£8/0/0** (plus 5/- carr. and ins.)

(Brief details of this unit are given on this page.)

THE FULL SPECIFICATION and BUILDING INSTRUCTIONS are available for 1/6.

THE ABOVE TWO UNITS COMPRISE A COMPLETE AMPLIFIER WHICH UNDOUBTEDLY IS BETTER THAN MANY OF THE "HIGH FIDELITY" AMPLIFIERS OFFERED AT DOUBLE OUR PRICE. **WE OFFER THE COMPLETE KIT OF PARTS TO BUILD BOTH UNITS FOR £16/16/0 or we supply completely assembled and ready for use for £19/19/0. H.P. Terms: Deposit £9/19/0 and 12 monthly payments of 18/7**

THE NEW ARMSTRONG FC48

A high-quality replacement Radio or Radiogram Chassis having provision for an FM Feeder Unit and incorporating separate BASS and TREBLE CONTROLS.
PRICE ASSEMBLED and READY FOR USE **£25/2/0** (Plus 7/6 carr. and insurance.)
H.P. Terms: £8/8/8 Deposit and 12 monthly payments of £1/10/6.

The B.S.R. Model TU.8 3-SPEED RECORD PLAYER

Supplied complete, including the new lightweight "Turnover" type Crystal Pick-up. **£4/12/6.**

Or we supply it without the Pick-up but including Turntable for **£2/18/-.**

The Latest COLLARO R.C.54 3-SPEED AUTOCHANGER. This is a "mixer" unit and incorporates the "Studio O" Crystal Pick-up. **£9/19/6.** H.P.: £5 dep. and 7 months at 17/2.

WE ALSO HAVE IN STOCK THE COLLARO MODEL 2010 PX TRANSCRIPTION RECORD PLAYER. S.A.E. FOR FULL DETAILS.

EXCEPTIONAL OFFER for CASH ONLY

This latest B.S.R. MONARCH 3-SPEED AUTO-CHANGER is offered for £7/19/6 (NORMAL PRICE £13/10/0)

- These units will autochange on all three speeds, 7in., 10in. and 12in.
- They play MIXED 7in., 10in. and 12in. records.
- They have separate sapphire for L.P. and 78 r.p.m., which are moved into position by a single switch.
- Minimum baseboard size required 14 x 12½in., with heigh above 5¼in., and height below baseboard 2½in. A bulk purchase enables us to offer these BRAND NEW UNITS at this *exceptional price.*

STERN'S "COMPACT 5" AMPLIFIERS

EXPRESSLY DEVELOPED FOR VERY HIGH QUALITY REPRODUCTION of GRAM. RECORDS AND PARTICULARLY SUITABLE FOR HIGH QUALITY REPRODUCTION OF THE F.M. TRANSMISSIONS: TWO MODELS ARE AVAILABLE:

The "Compact 5-2"
A 2-stage high sensitivity amplifier having SEPARATE BASS and TREBLE CONTROLS and designed to give up to approx. 5 watts with very pleasing quality PRICE **£5/15/-.**

The "Compact 5-3"
A 3-stage version of the "5-2" model, but in this case having an additional stage and incorporating negative feedback. PRICE **£6/16/-.**

The Amplifiers are compact and very attractively designed, having a Bronze/Gold finish with a fully engraved front panel by which the entire Amplifier is conveniently mounted into a Cabinet, occupying no more space than a conventional Tone Control Unit. **Fully described in our Leaflets. POWER SUPPLY.** A separate small Unit is available and this in addition to supplying power to the Amplifier has additional power available for RADIO TUNING UNIT, etc. PRICE **£2/10/-.**

DESIGNS FOR THE "HOME CONSTRUCTOR"

THE COMPLETE SPECIFICATIONS OF THE FOLLOWING UNITS ARE AVAILABLE FOR 1/6 EACH.

THESE MANUALS ALSO INCLUDE THEORETICAL and PRACTICAL WIRING DIAGRAMS, AND A COMPLETE COMPONENT PRICE LIST.

The "wire-to-wire" Practical Diagrams are very simple to follow and are drawn for the "inexperienced" constructor.

- **STERN'S F.M. TUNING UNIT . . .** This is illustrated and briefly described here and can be completely built for **£10.** It is now available.
- **STERN'S COMBINED AM/FM TUNING UNIT . . .** Precisely similar in appearance to the F.M. Tuner and can be completely built for **£13.** Will be available early June.
- **THE DENCO F.M. TUNING UNIT . . .** The complete set of SPECIFIED COMPONENTS to build this can be supplied for **£7/2/9,** this includes the Denco Dial and Drive Assembly.

NOTE TO CONSTRUCTORS . . . Where desired our technical staff will, at a reasonable charge, tune and align either of the above units.

- **STERN'S "fidelity" PRE-AMPLIFIER . . . TONE CONTROL UNIT . . .** A design for the "Hi-Fi" enthusiast!!! Briefly, it has inputs for MICROPHONES, HIGH and LOW GAIN PICK-UPS, and a RADIO TUNING UNIT. It incorporates (a) GRAM EQUALISING CONTROL, (b) STEEP CUT FILTER, (c) Continuously variable BASS and TREBLE CONTROLS and a VARIABLE OUTPUT CONTROL which enables its use with any make or type of Amplifier . . . THE COMPLETE KIT OF PARTS is available now for **£6/6/-.**
- **STERN'S "fidelity" 10 WATT AMPLIFIER . . .** This design comprises the MAIN AMPLIFIER of the famous MULLARD 5-10 design and our own "fidelity" PRE-AMPLIFIER-TONE CONTROL UNIT which we describe briefly above. We incorporate the latest GILSEN ULTRA-LINEAR OUTPUT TRANSFORMER and the combination of these two units undoubtedly provides reproduction of extremely high quality in fact the complete Amplifier is comparable to the very expensive commercially made High Fidelity models. We offer the COMPLETE KIT OF PARTS FOR **£16/16/-.** Will be available at the end of May.
- **STERN'S HIGH QUALITY 8-10 WATT AMPLIFIER . . .** This is illustrated and briefly described here. It is one of the most successful Amplifiers (in the lower price range) yet offered to the Home Constructor. We can supply the complete kit ex-stock.
- **STERN'S JUNIOR PRE-AMPLIFIER-TONE CONTROL UNIT . . .** Provides full control of BASS and TREBLE in conjunction with main VOLUME CONTROL and can be used with any Amplifier. The unit contains its own POWER SUPPLY . . . THE COMPLETE KIT OF PARTS is available at **£3/16/9.**

STERN'S Complete Kit for "HIGH QUALITY" 8-10 Watt Design.

THE IDEAL AMPLIFIER FOR GENERAL HOME USE

Price of COMPLETE KIT including Valves and Drilled Chassis, etc. **£7/10/0**

We supply it COMPLETELY BUILT for **£9/10/0**

Designed for High Quality reproduction up to an output level of 10 watts, having 6V6s in Push-Pull and incorporating negative feedback. It is suitable for use with all types of Pick-up and most types of microphone and the output transformer provides for use of 3- and 15-ohm speakers.

COMPLETE KIT OF PARTS STERN'S F.M. & combined AM/FM TUNING UNITS

A 5-valve Tuner incorporating the latest Mullard Permeability Tuning Heart and a "Magic Eye" Tuning Indicator. The performance of this is genuinely well up to the standard of the higher priced commercially made units and we recommend it with the utmost confidence.

THE COMBINED AM/FM TUNER is precisely similar in appearance to the above and incorporates 7 valves. It provides complete coverage of the F.M. Transmissions and the MEDIUM WAVEBAND thereby giving a good selection of foreign stations.

ALL COMPONENTS TO BUILD THESE AMPLIFIERS, TUNERS, ETC., ARE AVAILABLE FOR SALE SEPARATELY CONSTRUCTORS CAN THEREFORE GRADUALLY BUILD ANY UNIT.

STERN RADIO LTD. 109 and 115 FLEET ST., LONDON, E.C.4

When Ordering Please Include 5/- Extra for Carriage and Insurance. Telephone: FLE 5812/3/4

UNDOUBTEDLY THE BEST VALUE YET OFFERED

Stern's "fidelity" Tape Recorder

- Will play the new pre-recorded tapes
- Provides 2 hours playing time at 3¾" or 1 hour at 7½" per second
- Will take all standard reels up to 1,200 ft.
- Extension speaker sockets are provided
- Has dual input channels for mixing
- Monitoring provided for

GUARANTEED FOR 12 MTHS. (B.V.A. VALVES 90 DAYS)

SEND S.A.E. FOR ILLUSTRATED AND DESCRIPTIVE LEAFLETS

PRICE COMPLETE READY FOR USE £43

H.P. TERMS: Deposit £21/10/-. 12 monthly payments of £1/19/11. Carr. & ins. is £1 extra, but we return 10/- on return of packing case.

The following items form complete recorder.

HOME CONSTRUCTORS!! YOU CAN BUILD THE COMPLETE RECORDER FOR £40/-/-

or if you have your own Cabinet WE WILL SUPPLY:
The TRUVOX TAPE DECK, the TAPE AMPLIFIER, MATCHED SPEAKER, and 1,200ft. E.M.I. TAPE for £33/10/- plus £1 Carr. & ins., 10/- of which is refunded on return of packing cases.
The actual assembly of the Tape Recorder is extremely simple and only involves a few connections. The Truvox Tape Deck and the Quality Amplifier are supplied tested and ready for use, and all that is required to complete the Recorder is to connect the two together (a connection chart is supplied for this purpose) and secure them by the screws provided into the Attache Case.
H.P. TERMS ARE AVAILABLE. Send S.A.E. for complete details.

THE NEW TRUVOX MODEL TR7U TAPE DECK

3 Shaded-Pole motors. Drop-in Tape Loading. Push Button Control. Separate Push Button Brake. Fast forward and fast reverse. Silent drive eliminating Wow and Flutter. Half Track working and 2 speeds, 3¾in. and 7½in. per sec. Positive Azimuth Adjustment. Overall size only 14¼ x 12¼in. Available for £23/2/-.

THE MODEL T.R.I./F. QUALITY AMPLIFIER

Has been expressly designed to meet the requirements of enthusiasts for fidelity reproduction, and in particular to CORRECTLY operate the above TRUVOX DECK. It is supplied complete with a matched Elliptical 3 ohm P.M. Speaker, it incorporates an efficient Tone Control arrangement and has a Magic Eye Indicator (Operative on Record). A Co-axial Socket is also incorporated for MONITORING on Record, and this can also be used to feed an external amplifier. The Amplifier can also be used for high quality reproduction of gramophone records direct from a gram unit. Available for £14/14/-.

ACOS CRYSTAL MICROPHONE, MODEL MIC.33.1

Price £2/10/-.

1,200 ft. REEL OF SCOTCH BOY or E.M.I. MAGNETIC RECORDING TAPE.

Price £1/15/-.

PORTABLE ATTACHE CASE

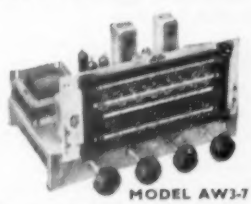
is a neat, compact and attractively finished case, being covered with maroon rexine and having an ivory coloured speaker escutcheon. It contains concealed pockets to accommodate the Microphone, Mains Lead and a spare 1,200ft. reel of tape. Price £5.

Modernise your old Radiogram

WE OFFER the latest 3 SPEED AUTOCHANGERS with modern RADIOGRAM CHASSIS and matched P.M. SPEAKERS at REDUCED PRICES. (H.P. Terms available) . . A good varied selection is offered . . . SEND S.A.E. for full DETAILS.

TWO REALLY GENUINE PRICE REDUCTIONS

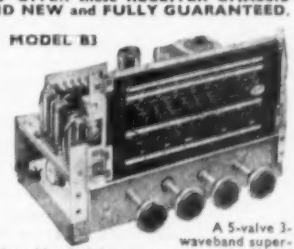
A BULK PURCHASE ENABLES US TO OFFER these RECEIVER CHASSIS at SUCH LOW PRICES. Each are BRAND NEW and FULLY GUARANTEED.



MODEL AW3-7

A 7-valve 3-waveband superhet chassis having a Push-Pull stage for approximately 6 watts output. PRICE **£12-19-6**
H.P. TERMS: Deposit £6/9/6 and 8 monthly payments of 18/9.

MODEL B3



A 5-valve 3-waveband superhet, identical in appearance to the Model B3PPP illustrated above but having a single valve (type 6BW6 output) for approximately 4 watts. PRICE **£11-11-0**
H.P. TERMS: Deposit £5/16/- and 7 monthly payments of 19/3

THESE TWO CHASSIS HAVE "GRAM" POSITION and are IDEAL REPLACEMENT CHASSIS FOR THAT "OLD RADIOGRAM"—Send S.A.E. for complete details.

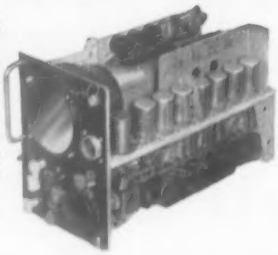
STERN RADIO LTD

109 & 115 FLEET ST., LONDON, E.C.4

Phone: CENtral 5812-3-4

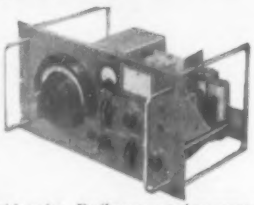
There is always a fine selection of equipment at

TYPE 62A INDICATORS



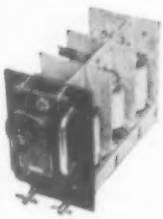
Ideal for conversion to oscilloscopes, T.V. units, etc. Containing V.C.R.97, 12 VR.91 (EF.50), 2 VR.54 (EB.34), 3 VR.92 (EA.50), 4 CV.118 (SP.61) Slow-motion dial, 13 Pots and scores of useful components. Size: 8½ × 11½ × 18in. In wooden packing case, £3, carriage 7/6.

RECEIVER TYPE 1132



11 valve Superhet. Frequency coverage 100-125 Mc/s. Valve line up: R.F. Amplifier VR.65 (SP.61). Frequency changer VR.65 (SP.61). Local Oscillator VR.66 (P.61). Stabiliser VS.70 (7455). 3 × I.F. Amplifiers VR.53 (EF.39). B.F.O. VR.53 (EF.39). Detector VR.54 (EB.34). A.F. Amplifier VR.57 (EK.32). Output VR.67 (6J5). Switchable A.G.C. and A.V.C. Variable B.F.O. Circuits diagrams with units. Easily converted to cover Wrotham Band with no alterations to wiring. Conversion Slugs and instructions, 2/6 extra. Size 19in. × 10in. × 10in. Standard Rack Mounting. £3/7/6. *Packing and carriage* 15/-, 10/- *returnable on packing case.*

R.F. UNITS



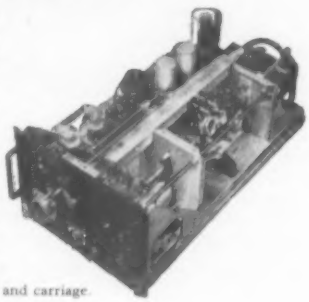
R.F.24 20-30 Mc/s. Switched Tuning. Valved. 9/6 each.

R.F.25 40-50 Mc/s. Switched Tuning. Valved. 9/6 each.

R.F.26 50-65 Mc/s. Variable Tuning. Valved (New and boxed) 25/- each.

Packing and postage 2/- each.

A.P.Q.9 RADAR JAMMING UNIT



Containing 913A Photo Multiplier Cell, complete with resistance network and lightproof box. Wide band amplifier (2) 6AC7 and 6AG7, driving a pair of parallel 807s which Grid modulate a pair of 8012s in push pull. Lecher lines, these cooled by blower motor. Cathode loaded by Co-axial stubs which simultaneously guillotine tune anode and grid lines with a counter mechanism. Output is matched to aerial by a matching stub. Suitable for use in centimetric bands. Brand new. Price £5, plus 10/- packing and carriage.

B.C. 610 TUNING UNITS

Types 49 and 50.

11/6 post paid.

POWER UNIT Type 173

12 or 24 Volt D.C. Input, 120V, 60 mA Output. Containing Vibrator Transformer, 12 Volt Vibrator, Two 120 Volt Selenium Rectifiers, Chokes and Condensers. Size 10½in. × 6in. × 3in. Price 12/6 post paid.

AN/APN1 UNITS

R.F. TRANSMITTER

A sub-chassis 3½in. × 6½in. × 2½in. containing a R.F. Transmitter operating 67.42 cm. (445 Mc/s) with a bandwidth of 40 Mc/s. Modulation of its carrier is by means of a Moving Coil Transducer with a metal diaphragm. The proximity of the diaphragme ffectively changes the resonant frequency of its tuned circuit, to produce frequency modulation. This transmitter utilises TWO 955 (VT 121) valves, and can quickly be converted for Radio Controlled Models; the frequency for this purpose being in the band, or for 70 cm. work.

PRICE, post paid **15/-**

RECEIVER

A sub-chassis 3½in. × 6½in. × 2½in. houses a Receiver tuned to the transmitting frequency. Contains TWO 9004 valves. For use in 70 cm. band.

PRICE, post paid **12/6**

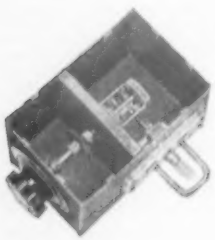
A.F. AMPLIFIER

An Audio Frequency Amplifier in a sub-chassis 5in. × 3in. × 3½in. R/C coupled, using TWO 12SH7 and ONE 12SJ7 valves; and can be used for Telephone Intercom., Pre-Amplifiers, etc.

PRICE, post paid **15/-**

SENSITIVE ALTIMETERS

0-45,000 feet. Suitable for climbers, Gliders and Car enthusiasts. In working order. Price 15/- each, p. & p. 3/-.



ABSORPTION WAVEMETER

Easily converted to 2 metres or 70 cm. In Copper-plated metal case 3½in. × 4½in. × 5½in. with dial calibrated 0-100 and 80 V Neon Tube. Coverage approx. 190-210 Mc/s. New, 6/6 each, post paid.

TRANSMITTER Type T1131-L

Frequency 100 to 156 Mc/s. Output 50W. Crystal controlled. 200-240V 50 c.p.s. Power supply. Housed in 6ft. standard 19in. rack. In new condition complete with valves. Send for full details.

THROAT MICROPHONES Type TS30

U.S. MANUFACTURE. Complete with elastic strap. Lead terminating at 2 pin plug PL.291. And Socket JJ-048. New and boxed, 3/- each, post paid.

ELECTRO MAGNETIC MICROPHONES

With switch and plug R.A.F. Type 48, new and boxed, 2/-each, p.p.

HAND GENERATOR (ex-Dinghy Transmitter) 28V, 175A and 300V 40mA output. Containing useful reduction gearing, housed in strong aluminium casting. Can be used for hand bench grinder, basis for megger, etc. Generator can be converted to mains motor. 15/-, p.p

All these fine offers are on display at ➔

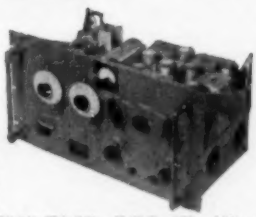
PROOPS BROS. LTD. — *The Walk-around Shop*

2 METRE RECEIVER TYPE R 1392

Air Tested

15 Valve Superhet

Frequency 95-150 Mc/s
(2 to 3 metres)



Valve line up: 1st and 2nd R.F. Amp. VR.136 (EF.54), 1st Local Oscillator VR.65 (SP.61), 2 Oscillator Multipliers VR.136 (EF.54). 3 I.F. Amp. VR.53 (EF.39). A.G.C. 6Q7. Output 6J5. Muting VR.92 (EA.50). Noise Limiter VR.92 (EA.50). B.F.O. 6J7. Mixer VR.136 (EF.54). De Mod. 6Q7. Slow motion Tuning over 95-150 Mc/s or can be Crystal controlled. Power supply required: 240-250 volts at 80 mA. 6.3 volts at 4 amps. Size 19in. × 10in. × 10in. Standard Rack Mounting. **£6/19/6.** Complete with valves and circuit diagram, checked and Air Tested. *Packing and carriage* 17/6, 10/- *returnable on packing case.*

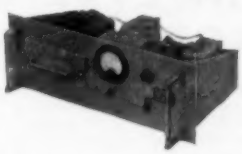
VALVE TESTERS MODEL 314

This model is of American manufacture and versatile, free-point return valve tester. Its design is such that it enables the user to test any type valves, regardless of its filament voltage or base wiring. Flexibility is attained by using individual lever switches of each valve element. Complete coverage of American Series including Acorns. Instruction manual supplied.

Price : complete in carrying case **£10** Plus 10/- carriage

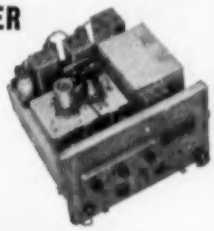
MAINS POWER UNIT TYPE 234

(For use with Receiver R 1392)



Double Smoothed 200-250 v. 505 Input. 240 V. 100 mA. 6.3 at 6 amps. with Volt Meter reading input and output voltages. Size: 19in. × 10in. × 6½in. Standard Rack Mounting. Price, £4/10/- each, plus 7/6 carriage.

ADMIRALTY RESPONSER UNIT W.4790



This Receiver tunes from 160-182 M/cs. valve line up VR.135 RF. VR.92 Mixer. VR.137 Osc. VR.65's in 5 I.F. stages.

Price : 12/6 each

Fully valved, post and pkg. 7/6.

TUNING UNITS TYPE T.U.5B

This well-known Tuning Unit has a frequency of 1500-3000 kc/s with 2% accuracy. Micrometer Dial that provides 2,500 divisions over 180° rotation of the tuning shaft which gives plenty of mechanical band spread from 3.5 Mc/s through 28 Mc/s. In addition the unit has a High C Tank Circuit with temperature compensating coil. The above Tuning unit from the BC-375 Transmitter needs only a few additional small parts to convert into a stable Temperature-Compensated VFO which may be used to replace the Crystal in Crystal controlled Transmitters. Conversion Details and Circuit Diagrams supplied FREE with unit. Price 15/- each, plus 4/- packing and carriage.

MINIATURE I.F. STRIPS

Size 10¾in. × 10½in. × 3in. frequency 9.72 Mc/s 2. EF.92's and 1 EF.91. I.F. amps. EB91. DET/AGC. EF.91 AGC. Amp. and EF.91. Limiter. Circuit supplied.

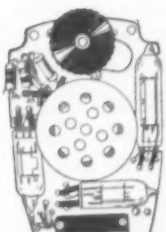
Price : 8/- less valves
Post paid.

BENDIX I.F. Transformers 1.63 Mc/s complete in cans, set of two new and boxed. Size: 2in. × 1¼in. × 3¼in., 5/-, p.p. 1/6.

BENDIX Potted Audio Output Transformer complete with integral smoothing choke. Ratings 4½ watt 9,000 ohm Primary. 600 and 4,000 ohm Secondary. Size: 4in. × 1¾in. × 2in. New and boxed, 4/6, p.p. 1/6.

INSULATION TAPE. Perfect condition, ½in. wide 25 yd. Reels foiled in tins, 1/3 each, p.p. 8d.

Make a miniature POCKET RADIO



Incorporating high "Q" technique using the New Ferrite rod. Made possible by simple conversion of an ex-Govt. Hearing Aid.

Technical Details. A Germanium Diode Detector circuit followed by the existing 3 valve Amplifier, giving adequate amplification throughout the medium wave band.

This conversion can be carried out in approximately 30 minutes.

SEE and HEAR this Miniature POCKET RADIO demonstrated.

THE COMPLETE KIT OF PARTS includes a Type OL10 Hearing Aid (with Crystal microphone) in perfect working order with miniature ear phone and moulded ear insert attached: ferrite rod, germanium diode, components, circuit diagram and full instructions.

Price **£2 6s. 0d.** post paid

ALL COMPONENTS SOLD SEPARATELY

Deaf Aid Unit with earpiece	£1	15	0
Plastic Ear Mould		2	0
Ferrite Rod		5	0
Conversion Components		4	0
Batteries 1.5 v. L.T. (Type D.18)			8
30 v. H.T. (Type B.119)		4	3

NOTE: As the crystal microphone is not used in the Pocket Radio, it can, if desired, be used as a general microphone and it does not require a matching transformer.

The Walk-around Shop

PROOPS BROS. LTD.

NOTE: Orders and Enquiries to Dept. "W" Shop hours 9 a.m. to 6 p.m.—Thurs.: 9 a.m. to 1 p.m.
OPEN ALL DAY SATURDAY. *Telephone : LANgham 0141*
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LASKY'S RADIO

SAVE POUNDS! ORDER BY POST IF YOU CANNOT CALL

HIRE PURCHASE TERMS

available on certain items. Write stating your requirements.

PROJECTION TV UNITS

(Mullard). Consisting of optical unit and E.H.T. unit, complete with valves and C.R. tube. Limited quantity. Full details on request.

LASKY'S PRICE £21
Carr. 21/-.

DECCA XMS P.U. HEADS

L.P. and standard, complete with styli. Per pair, 79/6
Post 3/6.
Singly, 42/-. Post extra.

SINGLE RECORD PLAYERS

Collaro 3/554..... £8 18 4
B.S.R. Model TU.8/.. £4 17 3
Garrard "TB" Units, less heads £8 10 11
Carr. 3/6.

ACOS TURNOVER CRYSTAL CARTRIDGES

HI/G type HGP.37, as used in latest radiograms. L.P. and standard. Complete with styli. 22/-.
Post 1/-.
Another well-known make at 18/6.

LASKY'S RECORD VALUE IN 3-SPD. MIXER AUTO-CHANGERS

ALL BRAND NEW AND UNUSED, IN MAKERS' CARTONS

Garrard RC.110, as illus. Complete with t.o. crystal pick-up. Cabinet space required 14 × 12½ × 4in. above, and 2½in. below motor board. Cream and brown enamel finish. Complete with instruction book. List £14/13/-.
LASKY'S PRICE £8.19.6
Carr. 5/-. Cabinets available, list on request.

Garrard RC.80. Full length arm with two Decca XMS heads. List £20/15/-.
LASKY'S PRICE £13.19.6
Carr. 5/-.
As above, with GC.2 t.o. crystal head, £15/15/-.

BSR Monarch. With HGP.37 t.o. crystal P.U. £7.19.6
Carr. 3/6.

Collaro RC.54. With Studio O t.o. crystal P.U. £9.19.6
Carr. 5/-.

THE BIGGEST BARGAIN EVER OFFERED IN TELEVISION CATHODE RAY TUBES!

Here's an offer you simply cannot afford to miss, but hurry, a limited number only are available. 16in. Metal Cone C.R. Tube, 6.3 v. heater, ion trap, 14 Kv. E.H.T., wide angle 70 deg., standard 38 mm. neck, duodecal base, magnetic focus and deflection. Max. length 17 11/16in.

Gives large black and white picture size 11 × 14¼in. Supplied unused in original cartons. Guaranteed by us for 3 months. Full data, connections and suggested time bases supplied with every tube.

LASKY'S PRICE
£9.19.6
Carr. and Insurance 22/6 extra.

LISTED AT £23.9.10

Masks, Anti-Corona Rings, Bases and Ion Traps available.

16 INCH METAL CONE C.R. TUBES MUCH BELOW HALF PRICE!

The Tube you have been waiting for! Big Picture Television at a price you can afford!

THE NEW JASON "ARGONAUT" AM/FM TUNER-RECEIVER

A super-sensitive Tuner-Receiver for F.M. and medium waves only. The complete parcel with output stage, £15.5.0
Post 3/6.
Data Book 2/-, post free.
All components available separately. Send for itemised price list.
Chassis Assembly, complete, 57/9. Post 2/6.
I.F. and Coil Set, complete 78/-. Post 1/6.

JASON F.M. TUNER

Special parcel containing data book, chassis, front end, dial, drive, tuning condenser, full set of coils, I.F.s, ratio detector, etc., 68/9
Post 2/6.
Book only, with price list, 2/-.
This Tuner uses 4-6AM6 and 2 crystals and can be built for £6/15/-, plus 3/6 post.

20,000 VALVES in stock. Send for our latest price list.

T.S.L. "EMPRESS" F.M. TUNER

A high-grade unit complete with power supplies. Incorporates the latest Gorler F.M. components including the permeability tuned front end. Freq. coverage 86-103 Mc/s. Two controls. Valve line up: ECC85, two 6BJ6, 6AL5, EZ80. Chassis only. £14.18
Post 3/6.
IN CABINET, with magic eye tuning indicator. £17.12.6
Post 3/6.
HANDBOOK giving full details for home construction, 2/6. Can be built for 10 gns. All components available separately.

DULCI F.M. TUNER

Incorporates its own power supply and provides complete F.M. coverage. Operates with most radio receivers and any make of Amplifier. Valve line up: EABC80 ECC85, two EF89, 6X4 (Rect.), EM80 Indicator. Incorporates GORLER Inductance Tuning Heart, and magic eye tuning indicator. Dial 10½ × 6in. Overall size 9 × 6 × 5½in. high. Complete 16 Gns.
Carr. & Pkg. 7/6.

12-CHANNEL TV TUNERS

Famous make. Covers Bands I and III. Complete with valves EF80 and ECC81. Ceramic valve holders, finest quality components. Switch and fine tuning. I.F. output 20-25 Mc/s. Freq. coverage 50-87 Mc/s. and 175-215 Mc/s. Full details and circuit diagram supplied. 89/6
Post 3/6. KNOBS 2/9 extra.
Also another Tuner using PCC84 and PCF80, I.F. output 33-38 Mc/s. Complete with valves and diagram, 99/6. Post 3/6

TELETRON BAND III CONVERTERS

MK. I. Complete Kit to build this converter, drilled chassis, condensers, resistances, coils, 2-E880 valves, etc., with circuit diagram and instructions. 48/6
Post 1/6.
Drilled chassis only, 3/0.

MK. II. Uses latest type valves. Cascode R.F. amp. and triode pentode F.C. PCC84 and PCF80, etc. The COIL SET. 17/6

COMPLETE KIT, including drilled chassis, valves and diagram, 59/6
Post 1/6.
Circuit diagram only, 2/6.

TELETRON CONVERTER COIL SET. For use with TRF and 8/het Band I TV sets. Uses two Z719. Circuit diagram alignments, full details supplied. 15/-
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WIDE ANGLE 14-INCH CONVERSION PARCEL

Convert to big 14in. picture! Parcel contains brand new 14in. rectangular C.R. Tube (famous make), 6.3 heater, 10-14 Kv. E.H.T. aluminised, 1 Ferroxcube line output trans. with width and linearity controls, Ferroxcube scanning coils, frame output trans., Ferroxdure focus magnet, duodecal base, 14in. mask, suggested circuit diagram. Complete parcel.
LASKY'S PRICE £18.5.0
Carr. and ins. 25/- extra.
All parts and C.R.T. available separately.

BAND III CONVERTERS

2 valves and metal rectifiers, metal case. Contains power pack for 200-250 v. A.C. List £8/10/-.
LASKY'S PRICE £5.19.6

DECCA PICK-UPS

3-speed with T.O. crystal head HI/G, and rest. Brown plastic. Post 2/6. 42/6

RADIO · TELEVISION · HI-FI · ELECTRONICS · RECORDERS

LASKY'S RADIO

3-WATT AC/DC MIDGET AMPLIFIER

Push pull, very high gain. 4 valves: two UL41 (p.p.) UCH42, UAF42. Input voltage 100/100 A.C./D.C. Easily converted to 230 v. Ideal for record players, tape recorders, baby alarms, etc. Supplied fully assembled with valves, circuit diagram and details. REDUCED TO **50/-**
Carr. 5/-.

TRANSISTORS and all Transistor components in stock.

LASKY'S RADIO CONSTRUCTOR PARCELS

No. 1. Contains everything to build a 4-valve, 3-wave superhet for 200-250 A.C. mains. Wood or plastic cabinet as preferred. Can be built for **£7.19.6**

No. 2. Contains everything to build a T.R.F. 3-valve, 3-wave set for 200-250 A.C. mains. Wood or plastic cabinet as preferred. Can be built for **£5.10**
Carr. 2/6.

INSTRUCTION BOOKS for above, 1/- each, post free. All components available separately.

FAMOUS AMPLIFIERS BUILT ON T.C.C. PRINTED CIRCUITS

All specified components used, with your choice of transformers and chokes. Fully assembled and ready for use.
The **MULLARD 510.** Price, according to transformers used, from **15 gns.** The Book, 3/6, post free.
THE OSRAM 912.
From **19 GNS.**
The Book, 4/-, post free.
All components available separately, also printed Circuits.

R1155 RECEIVERS

In original wood transit cases. Brand New	£11 19 6
Second-hand, Grade I	£9 19 6
Second-hand, Grade 2	£7 19 6

Carr. 12/6.
Power Pack and Output Stage with 6½in. Speaker.. £5 5 0

FILAMENT TRANSFORMERS

6.3 v. 1.5 amp	5 11
6.3 v. 3 amp	7 6
6.3 v. 1 amp	4 6
0-30 volts	19 6

STEEL CHASSIS

18 S.W.G. undrilled, 4 sides, reinforced corners. Depth 2½in.
6×4 4/-; 12×8 7/-; 16×10 8/3;
8×6 5/-; 14×9 7/6; 12×3 4/9;
10×7 6/-; 16×9 8/-; 12×6 6/6.
Post 1/- per chassis extra.

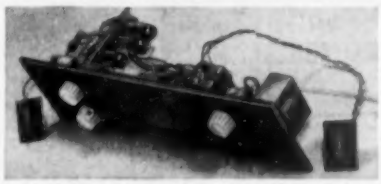
METER BARGAINS

2½in. moving coil. Brand new micro-ammeters F.S.D. 0-750 micro/amps., 15 ohms resist., 21/-. 0-1.5 amps., 12/6. 0-200 v. A.C., rect. incorporated, 12/6. Dozens of other types.

5-CHANNEL BAND I TV PRE-AMPLIFIERS

Famous make, brand new and unused. Contains one 6AM6 valve. Size 5×2×2in. List £2/5/-.
LASKY'S PRICE 21/-
Post 2/6.

SPECIAL OFFER OF PORTABLE GRAM AMPLIFIERS



Uses 3 latest miniature valves, U78, N78, DH77. Volume, bass and treble controls; extension L.S. socket and internal L.S. switch, indicator lamp Mounted on wood baffle, overall size 14×4½in. with speaker centralised. All top quality new components. For A.C. mains, 200-250 v. Ideal for portable record players, input will match Monarch, RC54, RC3/554, etc.
Price, complete with 3 new Osram valves, 7×4in. Goodmans elliptical speaker, metal speaker grille, mains lead, and knobs.
Post and Pkg. 5/-. **£5.9.6**

MOVING COIL SPEAKERS

5in.	6½in.	8in.	10in.	12in.
16/6	19/6	25/-	26/6	29/6

6½in. with trans..... 22/6
7 × 4in. Elliptical..... 19/6

COMPLETE 5-VALVE RADIO CHASSIS

Brand new and unused. A.C./D.C. 200/250 v. I.F. 465 kc/s. A.V.C., 4 watts output, 3-station pre-set, frame aerial, fully aligned, chassis 10×5½in., max. height 5½in. Completely wired and ready for use with the addition of a speaker and output transformer. Two controls, volume and station switch. Valves used: 10C1, 10F9 or UF41, 10LD11, 10P14, U404 or UY41.
NOW REDUCED TO less valves. **52/6**
Post 3/6.

HI-FI ELECTROSTATIC SPEAKERS ('TWEETERS')

For high fidelity sound reproduction. Easily fitted to any radio, TV set or amplifier. Full data and diagram supplied.

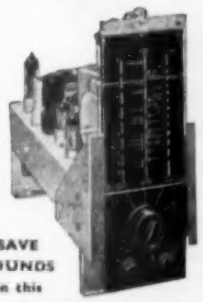
LSH100 (as illus.). 7-18 kc/s., 20 dbs., inherent cap. 1,100 p.f. For outputs up to 20 watts. Size 5 × 4 × ½in., 21/-.

LSH518. As above, for outputs of 10-12 watts (wide angle sound distribution). Size 7×2×½in. 17/6.

LSH75. Inherent cap. 800 p.f For outputs up to 6 watts. Size 3 × 3 × ½in. 12/6.
All post free.

LARGE STOCK OF HI-FI EQUIPMENT

Amplifiers, Speakers, etc. You saw and heard them at the Audio Fair, now buy at Lasky's



SAVE POUNDS on this

6 VALVE RADIOGRAM CHASSIS COMPLETE WITH VALVES

Famous Manufacturer's Surplus. 6 valve 3-wave Superhet. 13-50 m. short, 200-550 m. medium, 1,000-2,000 m. long. Brand new Mullard valves: ECH42, EF41, L63, EB41, 6V6 g.t., EZ40 and finest quality components. Gram, switch, 465 Kc/s I.F tone control, three-colour dial. Overall size, 13½×8in., height 12½in. Aperture required for dial and controls 11 × 3½in. Complete with valves, output trans., knobs, etc.
LASKY'S PRICE **£10-19.6**
Carriage and packing 7/6 extra.

5-VALVE RADIOGRAM CHASSIS

A.C. mains, 3-wave superhet. Large full vision dial, 11½ × 4½in. Overall dimensions 14 × 6 × 7in. Valve line-up: 12AN8, 6BA6, 6AT6, 6BW6, 6X4.
LASKY'S PRICE, complete with valves, **£9.19.6**
Carr. 7/6.
Table Cabinet for above, complete with 6½in. P.M. speaker, 49/9

MAKERS' SURPLUS TV COMPONENT BARGAINS

WIDE ANGLE 90 mm.

Line E.H.T. trans., ferrox-cube core, 9-16 kV	25/-
Scanning Coils, low imp. line and frame	25/-
Ferrox-cube cored Scanning Coils and Line Output Trans., 10-15 kV, EY91 winding. Line Trans. incorporates width and linearity control. Complete with circuit diagram, the pair	50/-
Frame Output Transformer	10/6
Scanning Coils low imp. line and frame	17/6
Frame or line blocking osc. transformer	4/6
Focus Magnets Ferrox-dure	19/6
P.M. Focus Magnets, Iron Cored	19/6
Duomag Focal Isers	22/6
300 m/a. Smoothing chokes	15/-
Electromagnetic focus coil, with combined scan coils	25/-

STANDARD 35 mm.

Line Output Transformers. No E.H.T.	12/6
Line Output Transformers 6-9 kV. E.H.T. and 6.3 v. winding. Ferrox-cube	19/6
Scanning coils. Low imp. line and frame	12/6
Ditto by Ignasic	14/6
Frame or line blocking oscillator transformer	4/6
Frame output transformer	7/6
Focus Magnets:	
Without Vernier	12/6
With Vernier	17/6
Focus Coils, Electro-magnetic	12/6
200 m/a. Smoothing Chokes	10/6

LATEST BRENELL TAPE EQUIPMENT

Deck. 3-speed, 3 motors, record and play back. **18 Gns.**
Amplifier Mk. II. 5 watts, for use with 3 ohms speaker. Magic eye. **18½ Gns.**
Carrying Case, **£5/18/-.**
Complete equipment with mike and tape, in carrying case, ready for use. **51 Gns.**
Full details on request.

RECORDING TAPE

Kraft base length 1,200ft. Cyldon metal spool. 12/11.
Post 1/-.
All makes of Tape stocked including the new thin long-playing tape. Scotch Boy, E.M.I., Grundig, Puretone, Ferrograph, Basf, Agfa, Gavaert. All types of spools.

LASKY'S (HARROW RD.) LTD.

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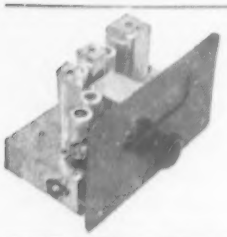
(50 yards only from Tottenham Court Road Tube !)
All post orders please to:—24-26, HAMPSTEAD RD., LONDON, N.W.1
EUSton 5533/4/5

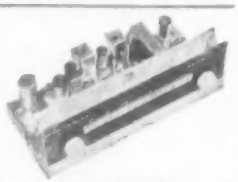
TELETRON BAND III CONVERTOR! Still available, this very popular convertor kit as illustrated and fully described in previous issues of the "W.W." For use with most T.R.F. or Superhet Band I T.V. Receivers. Construction details only, with separate individually priced parts list 6d. post free. Kit complete as specified 48/6, plus 2/- P. & P.
Mk. II Fringe area version kit complete 59/6, plus 2/- P. and P. Power pack kit for either of above 25/-.
We carry comprehensive stocks of all Band III Convertors by leading manufacturers. Also aerials, cross-over boxes, air-spaced low-loss co-axial cable at 10d. per yard. Let us have your enquiries. Any branded convertor supplied on H.P. terms!



THE JASON F.M. TUNER

Based on the booklet by Data Publications Ltd., 2/- post free, including our individually priced Parts List. Highly sensitive, free from drift. Incorporates 4 valves 6AM6 and 2 specially graded G.E.C. Crystals. The kit supplied includes drilled chassis with tuning condenser, scale calibrated in mc/s., and attractive bronze stove-enamelled front plate already mounted (illustrated). Front plate size 8in. × 5½in., chassis 7in. × 4½in. × 1¼in. Complete standard kit £6/15/- plus 2/6 p. and p. Fringe area kit £7/15/-, plus p. and p.

THE T.S.L. F.M. TUNER!



We can now supply this FM/VHF adaptor either in kit form, or fully assembled, wired and tested. Our price for the ready-built unit which incorporates its own power supply, is £13/15/- only tax paid, plus 5/- P. & P. or H.P. terms. Or the kit complete as specified £10/19/6 plus 2/6 P. & P. The booklet "F.M. TUNER CONSTRUCTION" (32 pages) with full technical data and point-to-point wiring diagrams, together with our separately priced parts list, is available at 2/6 post free.

THE GRADIENT F.M. TUNER FMT4. We are still able to offer our latest F.M. TUNER as illustrated and described in our previous advertisements. Illustrated comprehensive instruction booklet with individually priced component list 1/6 post free. Or, the kit complete right down to the last nut and bolt £6/19/6, plus 2/6 P. & P.

THE T.S.L. AM/FM CHASSIS!
Exceptional value. Covers L.M. and S.W. plus F.M.! 8-valve push-pull output. Ferrite rod aerial. Valve line-up: ECC85, ECH81, EF89, EABC80, ECC82, two 6BW6s plus 5y3. Large full-vision dial, size 14¼ × 6in. Chassis size, overall 15 × 7½ × 8in. high. Tax paid 26 guineas, plus 5/- packing and carriage. A supplementary extra is magic eye EM34, complete with escutcheon and fixing cable at 26/-. H.P. terms available. Demonstrations at 18 Tottenham Court Road!

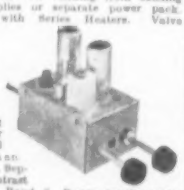
THE DULCI F.M. TUNER. Incorporates own power supply, suitable for use with any amplifier. Valve line-up: ECC85, two EF89, EABC80, 6 x 4, and EM80 indicator! Overall size: 9 × 6 × 5½in. high. Pre Budget price £16/16/- plus 5/-. P.P. Illustrated leaflet available, also H.P. terms.

SPECIAL OFFER!! Champion Model 835 FM/VHF Adaptor! Designed for the instant conversion of A.C. radiograms, table A.M. receivers and Hi-Fi audio amplifiers, to enable owners through their existing equipment to obtain the best results from the new F.M. transmission. Two connections only. One to the A.C. mains supply, the other to the pick-up sockets. Valve line-up: EF95, two EF80s, EB91, and EZ80. In attractive red and cream bakelite cabinet. Illustrated leaflet available on request. Price whilst stocks last only £13/19/6 tax paid, plus 3/6 P. & P. H.P. terms available.

DENCO F.M. TUNER. This highly successful kit is still available at inclusive price of £6/7/6 plus 2/6 P. & P. This kit includes all components and the five valves required for the extra I.F. Stage for fringe area reception. If required, "Denco" dial and drive assembly is available for the above at 5/- extra. Full constructional details 1/6 post free.

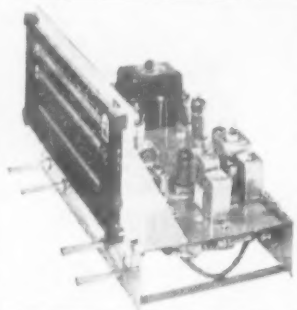
F.M. POWER PACK KIT. We can now supply complete kit for power pack suitable for the above F.M. tuners or any other similar type. Price for the complete kit is 37/6 only, or 50/6 for ready assembled unit. This pack is extremely small, incorporating valve rectifier type 6X4 and built on chassis size only 6 × 6 × 1¼in. Optional extra for power pack, Bulgin Octal Plug 2/3.

COMPETITIVE!! BAND III. CONVERTORS!



Type "M.L." for running from existing power supplies or separate power pack. Available with Series Heaters. Valve line-up: PCC84 and PCF80. Size: 4 × 2½ × 4½in. Fitted with external fine tuning control for Band 3 and Band 4/5 change-over switch. Separate contrast control for Band 3. Power requirements: H.T. 150/250 v. at 30 mA., L.T. 13/16 v. .3 amp. (Series Heaters). Unit simply fitted inside cabinet. Complete with handsome escutcheon. Available for A.C. operation with parallel heaters. ECC84 and ECF80 as above. Price £4/12/6. P. & P. 2/6. Full instructions supplied with each unit. Please specify whether required for London or Birmingham.

THE FAMOUS UNIVERTER—COMPARE THE PRICE!
Handsome walnut cabinet, finished in all areas. Contains own power supply. Simply connect to aerial. Four-valve circuit. Complete with all instructions £6/19/6 plus 3/6 P. & P.



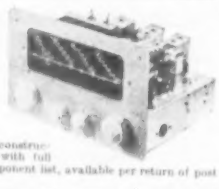
AM/FM RADIOGRAM CHASSIS! BARGAIN!

A special purchase of strictly limited quantity enables us to offer the following! For Medium, Long and F.M. Wavebands, plus gram position . . . Chassis size overall 13½in. long, 9in. high, 7½in. deep. Dial which is attractive red, green and gold lettering, on black background, measures 12in. × 5½in. horizontal. For A.C. mains, 200/250 v. Valve line-up ELS4, EABC80, EF85, ECH81, ECC85, EZ80, plus EM80 Magic Eye!! Limited quantity at bargain price of £18/19/6 only, plus 5/- P. & P. H.P. terms.

DULCI AM/FM CHASSIS H4

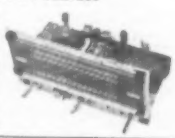
Illustrated leaflet available. L.M. and Short Waves plus F.M. This is a quality chassis 6 latest B.V.A. Mullard Valves, including magic eye. High Q. Inductances throughout, also Ferrite rods. Price is £27/16/- cash—or H.P. terms.

AM/FM KIT! FIRST AGAIN!



Introducing the **JASON AM/FM KIT** for medium waves and F.M.!
As illustrated this is a very high quality chassis incorporating 8 of the latest miniature valves, plus DM70 magic eye. Kits are available for chassis complete with output stage at £15/5/-. Also less output stage but with own built-in power pack at £13/19/6 only. These are high fidelity units and exceptional value at these prices which include all required components and full constructional details. Fully illustrated Data Booklet with full construction details, plus individually priced component list, available per return of post at 2/-, post free. Both plus 3/6 P. & P.

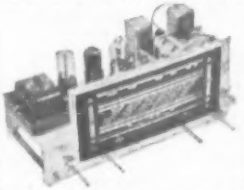
SPECIAL PURCHASE! MANUFACTURER'S SURPLUS



Owing to favourable purchase, we can offer strictly limited quantity of these handsome chassis. AC/DC 200/250 v. for Medium and Long Waves, plus gram position. Incorporates own frame aerial. Valve line-up: UF07, N108, DH107, W107 and X109. Overall chassis size 12 × 5½ × 7½in. high. Attractive bronze dial with gold and cr am lettering. Dial size 11½ × 4½in. Scale length 7½in. Logging scale provided. Price £7/19/6 only, tax paid, plus 3/6 P. & P. H.P. terms. £4 deposit plus four monthly payments of 22/-.

THE R.C. GRAM REPLACEMENT CHASSIS KIT.

Still available. Our very popular Gram Chassis replacement kit. For long, medium and short waves, and provision for gram. Valves 6K8, 6K7, 6Q7, 6V6 and 6X5.



For A.C. Mains 200/250 v. Chassis size 13½in. × 5½in. × 7½in. Dial size 10in. × 4½in. Assembly is simplified by use of ready assembled coil pack. Illustrated booklet with full assembly instructions, with itemised price list, is 1/6 post free—or the kit complete to last nut and bolt at £9/8/- plus 2/6 P. & P.

THE R.C.3/4 WATT AMPLIFIER KIT.

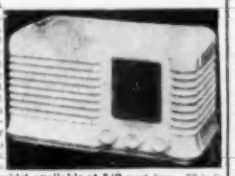
Just released! Compare the advantages! Treble bass, AND middle controls! For crystal or magnetic pickup! A.C. Mains 200/250 v. Valve line-up, 6V6GT, 6S07, metal GZ32. Negative feedback. Built on stove enamelled steel chassis, measuring only 8in. × 6in. × 1½in. Four engraved cream knobs are included in the price of the complete kit with all necessary practical and theoretical diagrams, at £4/5/- only, plus 2/6 packing and post, or Instruction Book fully illustrated, for 1/- Post free. This amplifier can be supplied assembled, tested, and ready for use at £5/5/- plus p. and p. Hearing is believing.

ACOS TYPE 7 Crystal Microphone Inserts Brand new, 7/6 each, post free.

Our advantageous H.P. terms are available on any single item over £5. Let us have your enquiries.

Please add postage under £1, or Cash with order. C.O.D. charge extra—open 9 a.m. to 6 p.m. Monday to Friday. Sorry but we close 1 p.m. on Saturday.

THE "ECONOMY FOUR" T.R.F. KIT. A three-valve plus metal rectifier receiver. A.C. mains 200/250 v. Medium and Long waves. We can supply all required components right down to the last nut and bolt. Valve line-up 6K7, 6J7 and 6V6. Chassis ready drilled—Cabinet size 12in. long by 6in. high by 5in. deep—Choice of ivory or brown Bakelite, or wooden walnut finish cabinet. Complete instruction booklet with practical and theoretical diagrams. Each component brand new and tested prior to packing. Our price **£5/10/-** complete—Remember this set is being demonstrated at our shop premises! We proudly claim that our fully illustrated instruction booklet is the most comprehensive available for this type of receiver—Booklet available at **1/6** post free. This is allowed if kit is purchased later. Plus 2/6 packing and carriage for complete kit.



THE "SUPERIOR" FOUR KIT. Our new four-valve receiver. A.C. mains 200/250 v. M. and Long waves. As with our very successful "Economy Four" all required components are supplied. Valve line-up: 2 6S67, 6 X56T and 6 V66T. Chassis ready drilled. Cabinet size, 16½in. × 10in. wide. Maximum depth at base 3in. tapering to 5¼in. at top. Sloping front. Very attractively finished in light walnut and peach. Each component brand new and tested prior to packing. Complete instruction booklet with practical and theoretical diagrams is provided. Booklet available at **1/6** post free. Our price for complete kit, **£6/9/6**. Please add 2/6 packing and carriage. If preferred, we can supply Cabinet Assembly only, comprising Cabinet and bracket wave-change switch, dial, pointer, drum pulleys, drive spindle, drive spring and knobs, at **45/-**, plus 2/6 packing and carriage. **N.B.**—Our kits are even supplied with sufficient solder for the job.

N.B. All our T.R.F. Kit circuits now include specially wound Denco "Maxi-Q" coils on polystyrene formers, improved performance! Price remains the same.

SURPLUS BARGAINS

METERS

F.S.D.	Size	Type	Fitting	Price
50 microamps	D.C. 2in.	M.C.	R.P.	50/-
50 microamp	D.C. 3½in.	M.C.	F.R. (Tropicalised)	85/-
50 microamp	D.C. 5in.	M.C.	Rectangular	120/-
50 microamp	D.C. 4in.	M.C.	Rectangular	110/-
50 microamp	D.C. 3½in.	M.C.	F.R.	85/-
100 microamp	D.C. 2½in.	M.C.	F.R.	45/-
200 microamp	D.C. 2in.	M.C.	F.R. (Tropicalised)	30/-
200 microamp	D.C. 3½in.	M.C.	F.R.	65/-
500 microamp	D.C. 2in.	M.C.	F.R.	18/6
1 mA.	D.C. 2in.	M.C.	F.R.	17/6
1 mA.	D.C. 2in.	M.C.	F. Sq. (1934 manufacture by Elliott)	35/-
1 mA.	D.C. 2½in.	M.C.	Desk Type	30/-
5 mA.	D.C. 2in.	M.C.	F. Sq.	10/-
50 mA.	D.C. 2in.	M.C.	F. Sq.	8/6
150 mA.	D.C. 2in.	M.C.	F. Sq.	8/6
500 mA.	D.C. 2½in.	M.C.	F.R.	10/6
.5 amp.	R.F. 2in.	Thermo	F. Sq.	6/6
1 amp.	R.F. 2½in.	M.C.	F.R.	10/-
20-0-20 amp.	D.C. 2in.	M.C.	F. Sq.	7/6
120-0-120 amp.	D.C. 2in.	M.C.	F. Sq. (shunt required)	15/-
150 amp.	A.C. 4in.	M.I.	R.P.	40/-
1 amp.	R.F. 2½in.	Thermo	R.P.	7/6
3 amp.	R.F. 2in.	Thermo	F. Sq.	6/-
5 amp.	D.C. 2in.	M.C.	F. Sq.	13/6
6 amp.	R.F. 2½in.	M.C.	Thermo F.R.	7/6
20 amp.	D.C. 2in.	——	R.F. (with shunt)	10/6
25 amp.	D.C. 2½in.	M.I.	F.R.	6/-
30 amp.	D.C. 2½in.	M.I.	F.R.	12/6
15 volt	A.C. 2½in.	M.I.	F.R.	10/-
20 volt (5 mA.)	D.C. 2in.	M.C.	F. Sq.	7/6
15-0-15 volt	D.C. 2½in.	M.C.	F.R.	17/6
300 volt	A.C. 2½in.	M.C.	F.R.	25/-
300 volt	A.C. 3½in.	M.I.	F.R.	30/-

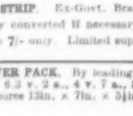
SPECIAL. U.S. 0-1 mA. 2½in. taken from equipment but perfect, **22/6** each. R.P. = Round Projection. M.C. = Moving Coil. Thermo = Thermo-coupled. F. Sq. = Flush Square. F.R. = Flush Round. M.I. = Moving Iron.

METER RECTIFIERS, 1 mA. by G.E.C., at **8/6**, also 5 mA. by G.E.C., at **8/6**.

COMMUNICATION RECEIVER PCR.2 3-wave band, 13-59, 190-570, 909-2,000 metres. Valve line-up 6V6, EBC33, X61 and 5-EF.39. Illuminated calibrated dial, fly-wheel tuning, aerial trimmer. In black crackle case size 17½in. × 10in. × 8in. Output socket for 3 ohm speaker, or headphones. Absolutely brand new in original cartons, manufactured for Govt. by PYE LTD.

Price **£7/10/-** only, plus p. and p. 10/-. With each set we supply full conversion details for A.C. mains. All required components for conversion available at **32/6** post paid. Limited quantity.

We can now supply already converted ready for A.C. Mains at **£9/19/6**, plus carriage. H.P. available.



METER SPECIAL! We have a limited quantity of aircraft electrical thermometers. Brand new, by Weston. 3in. moving coil meter, flush square case. These meters have a luminous scale graduated 40-140 degrees centigrade, but the full scale deflection is approximately 150 microamps! Price **12/6** each only, plus 1/- P. & P.

VIBRATOR PACK. Brand new, by Mallory 12 volt input, 150 v. 40 mA. output. Complete with synchronous vibrator, **17/6**.

COIL PACKS. Manufacturers' Surplus. Miniature size, only 2¼in. × 2¼in. × 1¼in. deep. Iron-cored. For L.M. and S.W. with gram. position. Switch has 2-inch spindle. Absolutely brand new, complete with circuit. Price only **27/6**, plus 1/6 P. & P. A snip!

AMERICAN INDICATOR UNIT TYPE BC929A. Brand new incorporating 3in. tube 3BP1, with mu-metal shield, 2-6SN7GT 2-6H6GT, 6X5G, 2X2, 6G6G, 9 potentiometers 24 v. aerial switch motor, transformer, and a host of small components. The whole unit which measures only 8½ in. × 6¼in. × 13¼in. is brand new, enclosed in black crackle box, and can be supplied at **45/-**, plus 5/- p. & p.

THE R.C. RAMBLER ALL-DRY PORTABLE KIT

Full assembly details with practical and theoretical diagrams can be supplied at **1/6** post free. This is a truly professional 4-valve superhet—all dry—for medium and long waves. A cream plastic top panel, with dial engraved in red and green adds to the very imposing appearance of this model which is housed in an attractive cream and grey leatherette covered attache-case type cabinet, measuring only 9in. × 7in. × 5¼in. Weight less batteries 4¼lb., with batteries 6¼lb. This set really has everything. Built-in frame aerial, high quality, extremely sensitive, and very adequate volume from the 5in. speaker. Valve line-up 3V4, 1R5, 1S5, 1T4. Also the required components, exactly as specified, including cabinet, can be supplied from stock at the special inclusive price of **£7/7/-** plus 2/6 p. and p. (less batteries). Uses Ever-Ready 90 v. H.T. type B126 at **9/3**. Also L.T. 1.5 v. A.D. 35 at **1/4**.

RAMBLER MAINS UNIT! At last we are able to offer our special mains units kit for using our popular all-dry "Rambler" on A.C. Mains. Complete kit, which when assembled fits snugly into battery compartment, can be supplied at 47/6, plus 1/6 packing and postage. Price includes all required components, and full assembly instructions. N.B.—This unit is completely self-contained in a metal box measuring 7in. × 3¼in. × 1¼in. and is ideally suitable for ANY all-dry battery portable requiring 90 v. H.T. and 1.5 v. L.T.

B.S.R. MONARCH. The very latest cream 3-speed mixer Auto-changer. Complete with turn-over crystal pick-up. Complete in original manufacturer's cartons, fully guaranteed. Price only **£7/19/6**. Buy now! Quantity at this price strictly limited.

JUST ARRIVED! Replacement pick-up cartridge for B.S.R. Monarch, etc., type HGP 37. Complete with sapphire stylii. Fitted in few seconds. Limited quantity at **19/6** only! Tax paid, post free!

TABLEGRAM CABINETS. Manufacturer's Surplus! Handsome dark walnut finish. Size 16¾in. × 13¼in. × 11¼in. high. Motor board already cut for latest type B.S.R. Monarch Auto-changer. Provision at side for amplifier controls. Price **75/6**, plus 5/- p.&p. Baffle fitted for 7in. × 4in. elliptical speaker for which we can supply Instant ROLA at **21/6**.

PORTABLE AMPLIFIER. To meet a universal demand, we have produced a quality amplifier, primarily for use with the Cabinet illustrated above, but ideally suitable for any portable record-playing equipment. Comprising EL84 (output), EABC80 (Triple Diode Triode) and metal rectifier (3 of KS2). For A.C. mains, including separate treble and bass controls. Chassis measures 6in. × 5in. Front plate 6in. × 4¼in. high. Price **09/6**, plus 2/6 p. & p. Engraved knobs to suit in white or brown at **1/3** each.

RC.84. Special Purchase! Latest type 3-speed, incorporating "T" type turnover head. Cream finish. Original manufacturer's cartons. **£9/19/6** only, plus 3/6 p. and p. H.P. terms available.

RECORD PLAYER CABINETS. Specially made to house any type of single record unit. Finished in dove-grey leatherette. Base-board measure 14¼in. × 12¼in. Clearance above and below board 8in., **45/-** plus 3/- P. & P. We can also supply equally attractive dove-grey cabinet to house any standard auto-changer at **69/6** plus 3/- P. & P. We carry a large selection of cabinets for all purposes. A stamp will bring illustrated cabinet leaflets.

RECEIVER TYPE 85/73. (The receiver section of TR1196). Supplied complete with full data for conversion to 2-wave superhet receiver. Unit is complete with 6 valves 2-EF39, 2-EF36, FK32 and EBC33, also stadard I.F.'s 465 Kc/s. Price **27/6** plus 2/6 P. & P.

TR1196 TRANSMITTER PORTION. We can also supply the transmitter portion of the above receiver incorporating valves, EL32, EF50, CV501. Type 600 relay transformer, coils, switches, etc. Limited quantity at **12/6** only, plus 2/6 P. & P.

VALVES

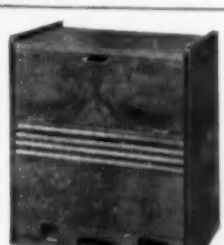
We have perhaps the most up-to-date valve stocks in the trade. A stamp will bring complete list but the following is a selection only of brand new imported valve types, fully guaranteed. Purchase Tax Paid.

EABC80	10/-	DAF96	10/6	PL83	11/6
EAF42	10/-	DF96	10/6	PY80	10/6
EB41	7/6	DK92	10/6	PY81	10/-
EB91	7/6	DK96	10/6	PY82	9/6
EBC41	10/-	DL96	10/6	PY83	11/6
EBF80	11/6	or 30/6 per set		UBC41	10/6
ECC81	9/-	of four.		UCH42	11/6
ECC82	9/-	EM70	9/-	UF41	10/6
ECC83	9/-	EL41	10/6	UL41	10/6
ECC84	15/-	EL84	11/6	UY41	9/-
ECC85	10/-	EM80	9/-	6AQ5	8/6
ECF82	15/-	EY51	12/-	6AT6	8/-
ECH42	11/6	EY86	14/6	6AU6	9/6
ECH81	11/6	EZ40	8/6	6BA6	8/6
ECL80	11/6	EZ80	8/6	6BE6	9/-
EF41	10/6	PCF80	12/6	6BW6	8/6
EF80	10/6	PCF82	12/6	6X4	7/6
EF85	10/6	PCL84	12/6	35W4	7/6
EF86	12/6	PL81	13/6	50B5	10/-
EF89	10/-	PL82	10/6	50C5	10/-

In addition we naturally have all usual surplus types available such as 6V6GT, etc. All in our valve price list!

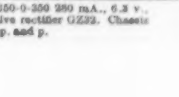
BRAND NEW C.R. TUBES. By leading manufacturer, 12in. equivalent to MW 31/74 **£11/19/6**. 14KP4A. Tinted. Latest type 14in. rectangular 6.3 v. heater, 12-14 Kv. in original sealed cartons. Limited quantity only at **£13/19/6**. Ditto 17in. type 17ASP4. Price **£18/19/6**. All H.P. available. Plus 15/- packing, carriage and insurance.

TRANSISTORS' MULLARD TYPE OC.71, Available ex stock at new list price of **30/-** each, post free.



Another Cabinet Bargain! Special purchase of walnut veneered trolley-type cabinets, originally intended for use in projection T.V. Easily recognised as being of leading High Quality manufacturer's stock, heavy dark solid walnut. Can be easily adapted to house tape recorder, amplifier, radiogram, etc., etc. Measurements external 24½in. × 16½in. × 29in. The whole is mounted on castors. Unrepeatable bargain at **£5/19/6**, plus 10/- packing and carriage. We have a large selection of all type cabinets. A stamp will bring list.

I.F. STRIP. Ex-Govt. Brand new condition, for 9.72 mc/s., but easily converted if necessary. Band width 180 kc/s. Less valves. Price **7/-** only. Limited supply.



POWER PACK. By leading manufacturer. Input 200/250 v. Output 350-0-350 280 mA., 6.3 v., 8 a., 6.3 v. 2 a., 4 v. 7 a., 5 v. 2 a. Fully smoothed. Incorporates valve rectifier GZ32. Chassis measures 13in. × 7in. × 5½in. Wt. 22lb. Few only at **£4/19/6**, plus 3/6 p. and p.

CLYNE RADIO LTD.

18, Tottenham Court Road, London, W.1.

R.S.C. BATTERY CHARGING EQUIPMENT

All for A.C. MAINS 200-250 v., 50 c/cs. Guaranteed 12 months.

ASSEMBLED CHARGER
6 v. or 12 v. 2 amps.
Fitted Ammeter and selector plug for 6 v. or 12 v. Louvred metal case, finished attractive hammer blue. Ready for use with mains and output leads. Double Fused.

Only **45/9** carr. 3/6.

ASSEMBLED CHARGERS

6 v. 1 amp.	19/9
6 v. or 12 v. 1 amp.	25/9
6 v. 2 amps.	29/9
6 v. or 12 v. 2 amps.	38/9
6 v. or 12 v. 4 amps.	56/9

Above ready for use. Carr. 2/9

HEAVY DUTY KIT
12 v. 30 amp. Suitable for Garage or firm with a number of vehicles. Mains input 200/250 v. 50 c/s. Outputs 12 v. 15 amp. twice. Consists of Mains Trans. 2 Metal Rectifiers. 2 Meters, 4 Fuses, 4 Terminals, 2 Rheostats and circuit. Only 9 gns., carr. 15/-.

BATTERY CHARGER KITS
Consisting of Mains Transformer, F.W. Bridge, Metal Rectifier, well ventilated steel case, Fuses, Fuse-holders, Grommets, panels and circuit. Carr. 2/6 extra.

6 v. or 12 v. 1 amp.	22/9
6 v. 2 amps.	25/9
6 v. or 12 v. 2 amps.	31/6
6 v. or 12 v. 4 amps.	49/9

BATTERY CHARGER KIT
Consisting of F.W. Bridge Rectifier 6/12 v. 5 a. Mains Trans., 0–9–15 v. 6 a. output, and variable charge rheostat with knob. Only 45/9. Post 3/-.

Assembled 6 v. or 12 v. 4 amps.
Fitted Ammeter and variable charge selector. Also selector plug for 6 v. or 12 v. charging. Double fused. Well ventilated steel case with blue hammer finish. Ready for **69/6** use with mains and output leads. Carr. 3/6.

SELENIUM RECTIFIERS

L.T. Types		6/12 v. 6 a.	19/9
2/6 v. ½ a.h.w.	1/9	6/12 v. 10 a.	25/9
6/12 v. ½ a.h.w.	2/9	**H.T. Type H.W.**	
F.W. Bridge Types		120 v. 40 mA.	3/9
6/12 v. 1 a.	5/9	250 v. 50 mA.	5/9
6/12 v. 2 a.	8/9	250 v. 80 mA.	7/9
6/12 v. 3 a.	12/9	250 v. 150 mA.	9/9
6/12 v. 4 a.	16/9	300 v. 275 mA.	12/11

CO-AXIAL CABLE. 75 ohms ½in., 8d. yard. Twin screened feeder, 11d. yard.

T.V. CABINETS. Console type for 15, 16 or 17in. tube. Half length doors, 9 gns. Table model with doors for same size tube, 69/6. Table top for 12in. Tube 29/6. All famous manufacturers surplus.

SILVER MICA CONDENSERS. 5, 10, 15, 20, 25, 30, 35, 50, 100, 120, 150, 180, 200, 230, 300, 330, 400, 470, 500, 1,000 pfd. (.001μF), .002 mfd. (2,000 pfd.). All at 6d. each, 3/9 dozen one type.

DIAL BULBS, M.E.S., 8 v. 0.2 a., 6/9 doz. 6.5 v. 0.3 a., 6/9 doz.; 4 v. 0.3 a., 5/9 doz.

ELECTROLYTICS (current productions). NOT Ex-Govt.

Tubular Types		Can Types	
8μF 450 v.	1/9	8 mfd. 350 v.	1/3
8 mfd. 500 v.	2/6	8 mfd. 600 v.	2/11
16μF 350 v.	2/3	16 mfd. 500 v.	3/9
16μF 450 v.	2/9	16 mfd. 350 v.	1/11
16μF 500 v.	3/9	16μF 450 v.	2/9
32μF 350 v.	3/9	32μF 350 v.	2/11
32 mfd. 500 v.	5/9	32 mfd. 450 v.	4/9
8-16μF 500 v.	4/11	100 mfd. 450 v.	4/9
25μF 25 v.	1/3	8-8μF 450 v.	2/11
50μF 12 v.	1/3	8-16μF 450 v.	2/11
50μF 50 v.	1/9	16-16μF 450 v.	3/11
100 mfd. 12 v.	1/9	16-32μF 350 v.	4/9
100 mfd. 25 v.	2/3	32-32μF 450 v.	5/9

Many others in stock.

VOLUME CONTROLS with long spindles, all values, less switch, 2/9; with S.P. switch, 3/9.

VIBRATORS. Oak 2 v. 7 pin. synchronous, 7/9.

EX GOVT. E.H.T. CONDENSERS

.5 mfd., 2,500 v. Blocks	3/9
.5 mfd. 3,500 v. Cans	3/3
.1 mfd. plus 1 mfd. 8,000 v., large blocks (common negative isolated)	9/6

EX GOVT. METAL BLOCK PAPER CONDENSERS

2 mfd. 500 v.	1/9	4 mfd. 1,500 v.	4/9
4 mfd. 500 v.	2/9	8 mfd. 500 v.	5/9
4 mfd. 1,000 v.	4/3	8-8 mfd. 500 v.	5/11
4 mfd. 400 v. plus 2 mfd. 250 v.		15 mfd. 500 v.	7/9
			1/11

EX GOVT. VALVES. VR137, EA50, EB34 11d.; SP61 2/3; 4SHA 1/3; EL32 3/9.

EX GOVT. UNITS, type RDF1 in original sealed cartons with 14 valves including 5Z4G etc., trans., L.F. choke, Rectifier etc., etc. We cannot enter into correspondence regarding these units which represent a really exceptional bargain at 28/9. Carr. 7/6. Transmitter Receivers type TR9D complete with all valves 45/-, carr. 6/6.

CONTROL PANEL with 1 six-position 3-wafer Yaxley switch, 1 pointer knob. 2 S.P.S.T. switches, various plugs and sockets. Only 1/6.

OIL FILLED BLOCK CONDENSERS
Bryce 11-7 mfd. 500 v. New unused Govt. surplus, only 5/9 each.

EX GOVT. MAINS TRANSFORMERS
All 230 v. 50 c/s. input.

8.8 v. 4 a., 9/9. 120-0-120 v. 40 mA.	5/9
300-0-300 v. 150 mA. 4 v. 3 a.	9/9
250-0-250 v. 60 mA. 6.3 v. 2 a., 5 v. 2 a. Potted 41-31-3in.	11/9
460 v. 200 mA., 6.3 v., 5 a.	22/9

0-16-18-20 v. 35 a. 79/6. Carriage 5/- extra.

MANUFACTURERS SURPLUS TRANSFORMERS
Fully shrouded upright. Primary 200-230-250 v. Sec. 425-0-425 v. 150 mA. 6.3 v. 3 a., 5 v. 3 a., 33/9. Clamped type 250-0-250 v. 70 mA., 6.3 v. 2.5 a. 9/9, post 1/9.

EX GOVT. SMOOTHING CHOKES

250 mA., 10 H., 50 ohms	14/9
250 mA., 3 H., 50 ohms	8/9
150 mA., 10 H., 50 ohms	10/11
150 mA., 6–10 H., 150 ohms., Tropicalised	6/9
100 mA., 10 H., 100 ohms, Parmeko	6/9
100 mA., 10 H., 200 ohms, Tropicalised	3/11
50 mA., 50 H., 1,000 ohms	6/9
L.T. type 1 amp., 2 ohms	2/9

SPECIAL OFFERS. Small 2 gang variables .0005 mfd., 4/9. 8-8 mfd., 450 v. Electrolytics (midget) in lots of six, 1/6 ea.

R.S.C. BATTERY TO MAINS CONVERSION UNITS

Type BM1. An all dry battery eliminator. Size 5½ x 4½ x 2in. approx. Completely replaces batteries supplying 1.4 v. and 90 v. where A.C. mains 200-250 v. 50 c/cs. is available. **Suitable for all battery portable receivers requiring 1.4 v. and 90 v.** This includes latest low consumption types. Complete kit with diagrams 39/9, or ready for use, 46/9.

Type BM2. Size 8 x 5½ x 2¼in. Supplies 120 v., 90 v., and 60 v., 40 mA. and 2 v. 0.4 a. to 1 amp., fully smoothed **THEREBY COMPLETELY REPLACING BOTH H.T. BATTERIES AND L.T. 2v. ACCUMULATORS.** When connected to A.C. mains supply 200-250 v. 50 c/cs. SUITABLE FOR ALL BATTERY RECEIVERS normally using 2 v. accumulator. Complete kit of parts with diagrams and instructions 49/9, or ready for use 59/6.

PLESSEY DUAL CONCENTRIC 12in. P.M. SPEAKERS. (15 ohms), consisting of a high quality 12in. speaker, of orthodox design supporting a smaller elliptical speaker ready wired with choke and condensers to act as tweeter. This high fidelity unit is highly recommended for use with our A8 or any similar amplifier. Rating is 10 watts. Price only £5/17/6.

R.S.C. TRANSFORMERS

FULLY GUARANTEED, INTERLEAVED AND IMPREGNATED

MAINS TRANSFORMERS
Primaries 200-230-250 v. 50 c/s.

FULLY SHROUDED UPRIGHT MOUNTING

250-0-250 v. 60 mA. 6.3 v. 2 a., 5 v. 2 a., Midget type, 2½-3-3in.	17/6
350-0-350 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a.	19/9
250-0-250 v. 100 mA., 6.3 v.–4 v. 4 a., c.t., 0-4-5 v. 3 a.	25/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
250-0-250 v. 100 mA., 6.3 v. 6 a., 5 v. 3 a., for R1355 conversion	31/-
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
300-0-300 v. 100 mA., 6.3 v. 4 v. 4 a., c.t., 0-4-5 v. 3 a.	26/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
350-0-350 v. 100 mA., 6.3 v.–4 v., 4 a., c.t., 0-4-5 v. 3 a.	26/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	33/9
350-0-350 v. 150 mA., 6.3 v. 2 a., 6.3 v. 2 a., 5 v. 3 a.	33/9
425-0-425 v. 200 mA., 6.3 v. 4 a., c.t., 6.3 v. 4 a. c.t., 5 v. 3 a. suitable Williamson Amplifier, etc.	49/9
450-0-450 v. 250 mA., 6.3 v. 6 a., 6.3 v. 6 a., 5 v. 3 a.	69/6

TOP SHROUDED DROP-THROUGH TYPE

250-0-250 v. 70 mA., 6.3 v. 2.5 a.	13/9
260-0-260 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a.	16/9
350-0-350 v. 80 mA., 6.3 v. 2 a., 5 v. 2 a.	18/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	22/9
300-0-300 v. 100 mA., 6.3 v.–4 v. 4 a., c.t., 0-4-5 v. 3 a.	23/9
350-0-350 v. 100 mA., 6.3 v. 4 a. c.t., 5 v. 3 a.	22/9
350-0-350 v. 100 mA., 6.3 v.–4 v. 4 a. c.t., 0-4-5 v. 3 a.	23/9
350-0-350 v. 150 mA., 6.3 v. 2 a., 6.3 v. 2 a., 5 v. 3 a.	29/11
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	29/9
E.H.T. TRANSFORMERS, 2,500 v. 5 mA., 2-0-2 v. 1.1 a., 2-0-2 v. 1.1 a., for VCR97, VCR517	36/6

FILAMENT TRANSFORMERS
Primaries 200-250 v. 50 c/s.

6.3 v. 1.5 a.	5/9	0-2-4-5-6.3 v.	
6.3 v. 3 a.	8/11	4 a.	16/9
12 v. 1 a.	7/9	6.3 v. 6 a.	17/6
6.3 v. 2 a.	7/6	12 v. 3 a. or	
0-4-6.3 v. 2 a.	7/9	24 v. 1.5 a.	17/6

CHARGER TRANSFORMERS
All with 200-230-250 v. 50 c/s. Primaries: 0-9-15 v. 1½ a., 11/9; 0-9-15 v. 3 a., 0-3.5-9-17 v. 4 a., 18/9; 0-9-15 v. 5 a., 19/9; 0-9-15 v. 6 a., 23/9.

ELIMINATOR TRANSFORMERS

Primaries 200-250 v. 50 c/s. 120 v. 40 mA.	7/11
130 v. 50 mA., 6.3 v. 3 a.	14/9
120 v. 40 mA., 5-0-5 v. 1 a.	14/9
90 v. 15 mA., 6-0-6 v., 250 mA.	9/11

OUTPUT TRANSFORMERS

Midget Battery Pentode 66 : 1 for 3S4, etc.	3/6
Small Pentode, 5,000Ω to 3Ω	3/9
Standard Pentode, 5,000Ω to 3Ω	4/9
Standard Pentode, 8,000Ω to 3Ω	4/9
Battery Pentode, 10,000 ohms to 3 ohms.	4/9
Multi-ratio 40 mA. 30 : 1, 45 : 1, 60 : 1, 90 : 1, Class B Push-Pull	5/6
Push-Pull 8 Watts 6V6 to 3Ω or 15Ω	8/9
Push-Pull 10-12 Watts 6V6 to 3Ω or 15Ω	15/9
Push-Pull 10-12 Watts to match 6V6 to 3-5-8 or 15Ω	16/9
Push-Pull 15-18 Watts, sectionally wound, 6L6, KT66, etc., to 3 or 15 ohms	21/9
Push-Pull 20 Watt high-quality sectionally wound, 6L6, KT66, etc., to 3 or 15Ω	47/9
Williamson type exact to spec.	85/-

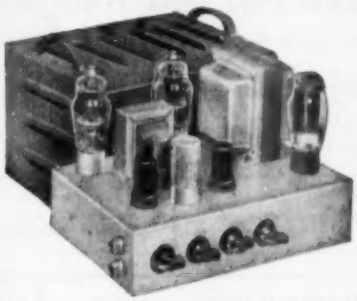
SMOOTHING CHOKES

250 mA., 5 H., 100 ohms.	11/9
150 mA., 7-10 H., 250 ohms.	11/9
100 mA., 10 H., 200 ohms	8/9
80 mA., 10 H., 350 ohms.	5/6
60 mA., 10 H., 400 ohms.	4/11

R.S.C. A6 ULTRA LINEAR 30 WATT AMPLIFIER

NEW 1956 DESIGN. HIGH FIDELITY PUSH-PULL UNIT EMPLOYING SIX VALVES. Tone Control Pre-amp stages are incorporated. Sensitivity is extremely high. Only 30 millivolts minimum input is required for full output. **THIS ENSURES THE SUITABILITY OF ANY TYPE OR MAKE OF MICROPHONE OR PICK-UP.** Separate Bass and Treble controls give both "lift" and "cut" with ample tone correction for long playing records. **AN OUTPUT SOCKET WITH PLUG IS INCLUDED FOR SUPPLY OF 300 v. 20 mA. and 6.3 v. 1.5 a. FOR A RADIO FEEDER UNIT.** Price in kit form with easy to-follow wiring diagrams. **9 GNS.** Carr. 10/- Only

Or Factory built with 12 months' guarantee, 50/- extra. **H.P. TERMS ON ASSEMBLED UNITS: DEPOSIT 28/6** and 12 monthly payments of 21/-. If required an extra input with associated vol. control can be provided so that two separate inputs such as "mike" and gram., etc., etc., can be simultaneously applied for mixing purposes. Extra cost for this 13/-. Cover as illustrated 17/6 extra.



Type 807 output valves are used with High Quality Sectionally wound output transformer specially designed for Ultra Linear operation. Negative feedback of 17 D.B. in main loop. **CERTIFIED PERFORMANCE FIGURES ARE EQUAL TO MOST EXPENSIVE UNITS AVAILABLE.** Frequency response ± 3 D.B. 30-20,000 c/cs., 12 D.B. "lift" at 50 c/cs., 12 D.B. "lift" at 12,000 c/cs. Hum and noise 70 D.B. down. Good quality reliable components used. Chassis finish blue crackle. Overall size 12×9×9in. approx. Power consumption 150 watts. For A.C. mains 200-230-250 v. 50 c/cs. Outputs for 3 and 15 ohm speakers. **EQUALLY SUITABLE FOR THE CONNOISSEUR OR FOR LARGE HALLS, CLUBS, or OUTSIDE FUNCTIONS. IDEAL FOR USE WITH MUSICAL INSTRUMENTS SUCH AS STRING BASS, ELECTRONIC ORGAN, GUITAR, etc. FOR DANCE BANDS, GARRISON THEATRES, etc., etc.**

We can supply Microphones, Speakers, Rotary Converters, etc., at keen cash prices or on H.P. terms with amplifiers.

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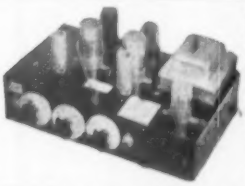


R.S.C. TA1 HIGH QUALITY TAPE DECK AMPLIFIER FOR ALL DECKS WITH HIGH IMPEDANCE RECORD/PLAYBACK AND ERASE HEADS. Such as Lane, Truvox and Collaro Studrad transcriptor chassis. Size 12-7-5in. **Overall size** 19-7-6½in. For 230-250 v. 50 c/cs A.C. mains. Output for standard 2-3 ohm speaker. Only 15 millivolts input required for full recording. Only 2 millivolts minimum input required from recording head. Magic Eye recording level indicator. Provision for feeding P.A. amplifier. Can be used as gram. amplifier with input of 0.75 v. R.M.S. Negative feedback equalisation. Linear frequency response ± 3 D.B. 50-11,000 c/cs.

11 GNS. Carr. 7/6

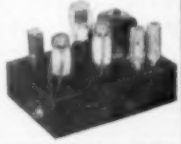
Ready for use. **Facilities for recordings at 15in., 7½in., or 3¾in. per second. Automatic equalisation at the turn of a knob.** When switching from record to playback position automatic demagnetisation of heads is assured. PERFORMANCE IS COMPARABLE WITH UNITS AT OVER TWICE THE COST. LEAFLET 6d.

GARRARD 3-SPEED AUTOMATIC RECORD CHANGERS. Latest Model. Type RC110. Fitted high fidelity turnover crystal pick-up head. For 200-250 v. A.C. mains. Limited number. Brand new cartoned. Only **£8/17/6**, plus 5/6 carriage.

H.M.V. LONG PLAYING RECORD TURNTABLE COMPLETE WITH CRYSTAL PICK-UP (SAPPHIRE STYLUS). Speed 33¼ r.p.m. BRAND NEW. CARTONED. Only £3/19/6 (approx. half price). Carr. 9/- (for 200-250 v. A.C. Mains).

MICROPHONES. High fidelity crystal types. Acos 39-1 hand or desk type. 50/-. Pizzo with heavy floor base and telescopic stem. **£6/19/6.**

R.S.C. 4-5 WATT HIGH GAIN AMPLIFIER TYPE A5



A highly sensitive 4-valve quality amplifier for the home, small club, etc. Only 50 millivolts input is required for full output so that it is suitable for use with the latest high-fidelity pick-up heads in addition to all other types of pick-ups and practically all mikes. Separate Bass and Treble controls are provided. These give full long playing record equalisation. Hum level is negligible, being 71 D.B. down. 15 D.B. of negative feedback is used. H.T. of 300 v. 26 mA. and L.T. of 6.3 v. 1.5 a. is available for the supply of a Radio Feeder Unit, or Tape Deck pre-amplifier. For A.C. mains input of 200-230-250 v. 50 c/s. Output for 2-3 ohm speaker. Chassis is not alive. Kit is complete in every detail and includes fully punched chassis (with baseplate) with blue hammer finish, and point-to-point wiring diagrams and instructions. Exceptional value at only £4/15/-, or assembled ready for use 25/- extra, plus 3/6 carriage.

R.S.C. A73-4 WATT QUALITY AMPLIFIER

A highly sensitive 4-valve amplifier using negative feedback and having an excellent frequency response. Pre-amplifier and Tone Control stages are incorporated with separate Bass and Treble controls giving full tone compensation for Long Playing records. Suitable for any kind of pick-up including latest high fidelity types. H.T. of 250 v. 20 mA. and L.T. 6.3 v. 1 a. available for supply of Radio Feeder Unit, etc. ONLY 40 millivolts input required for full output. Fully isolated chassis with baseplate. For A.C. mains 200-250 v. 50 cycles. Output for 2-3 ohm speaker. Complete kit of parts with point-to-point wiring diagrams and instructions. Only £3/15/-, carr. 3/6 or factory built 22/6 extra.

BRAND NEW B.S.R. MONARCH 3-SPEED MIXER AUTO-CHANGERS. With crystal pick-up and dual point sapphire styli for standard or long playing records. Plays ten 7in., 10in., or 12in. intermixed. For A.C. mains 200-250 v. 50 c/cs. Supplied in sealed cartons with turntable and operating instructions. Only **£7/19/6** plus 3/6 carr.

WALNUT VENEERED CABINETS. Designed for above record changers with provision for housing amplifier and speaker. Attractive design. Limited number. Brand new cartoned **£3/19/6**, carr. 7/6.

QUALITY AMPLIFIERS, 3-4 watt, specially designed for use with B8R changer and above cabinet. Latest miniature type valves used. For A.C. 200-250 v. mains, **£3/19/6.**

P.M. SPEAKERS. Suitable for use with above equipment. Elliptical 6 × 4 ins. with 2-3 ohm speech coil, **18/9** ea.

COLLARO HIGH FIDELITY MAGNETIC PICK-UPS. Low impedance with matching trans., brand new, boxed at fraction of normal price. Only **31/-.**

THE SKY FOUR T.R.F. RECEIVER

A design of a 5-valve 200-250 v. A.C. Mains receiver with selenium rectifier. For inclusion in either of cabinets illustrated above. It employs valves 6K7, 6F61, 6F66, and is specially designed for simplicity in wiring. Sensitivity and quality is well up to standard. Point-to-Point wiring diagrams, instructions and parts list, 1/2. This receiver can be built for a maximum of **£4/19/6** including cabinet. Available in brown or cream bakelite, veneered walnut.

FOUR-STAGE RADIO FEEDER UNIT

Design of a HIGH FIDELITY L. and M. wave T.R.F. Unit with self-contained heater supply and thorough H.T. decoupling. Only 200-400 v. 15-20 mA. H.T. required from main amplifier. Three valves and Low Distortion Germanium Diode Detector. Flat topped response characteristic. Loaded H.F. coils. Two variable Mu controlled H.F. stages, 3 gang condenser tuning. Cathode follower output stage. Switch position for Gram. and Gram. input and output sockets. Performance comparable with the best in Feeder Units. For A.C. mains 200-230-250 v. operation. Size 11-6-7½in. Illustrations full set or easy-to-follow wiring diagrams and instructions and individually priced parts list 2/6. This unit can be built for only £3/15/-, including Dial and Drive knobs and every item required.

DEFIANT RECORD PLAYING TURNTABLE COMPLETE WITH MAGNETIC PICK-UP. Pick-up to high impedance type. Unit is housed in a beautiful walnut veneered cabinet of attractive design. For all standard records (78 r.p.m.). Limited number. Brand new, cartoned, **£5/19/6**, carr. 7/6.

W.B. "STENTORIAN" HIGH FIDELITY P.M. SPEAKERS. HF1012, 10 watts, 15 ohm (or 3 ohm) speech coil. Where a really good quality speaker at a low price is required, we highly recommend this unit with an amazing performance, **£4/10/9.** Please state whether 3 ohm. or 15 ohm. required.

R.S.C. ULTRA LINEAR 12-WATT AMPLIFIER

NEW 1956 Model A8 High-Fidelity Push-Pull Amplifier with "Built-in" Tone Control, Pre-amp. stages. High sensitivity. Includes 5 valves (807 outputs), High Quality sectionally wound output transformer, specially designed for Ultra Linear operation, and reliable small condensers of current manufacture. INDIVIDUAL CONTROLS FOR BASS AND TREBLE "Lift" and "Cut." Frequency response ± 3 db. 30-20,000c/cs. Six negative feedback loops. Hum level 71 db. down. ONLY 70 millivolts INPUT required for FULL OUTPUT. Suitable for use with all makes and types of pick-ups and practically all microphones. Comparable with the very best designs. For STANDARD or LONG PLAYING RECORDS. For MUSICAL INSTRUMENTS such as STRING BASS, GUITARS, etc. OUTPUT SOCKET with plug provides 300 v. 20 mA. and 6.3 v. 1.5 a. For supply of a RADIO FEEDER UNIT. H.P. TERMS ON ASSEMBLED UNITS. DEPOSIT 25/6 and nine monthly payments of 22/4. Size approx. 12-9-7in. For A.C. mains 200-230-250 v. 50 c/cs. Output for 3 and 15 ohm speakers. Kit is complete to last nut. Chassis is fully punched. Full instructions and point-to-point wiring diagrams supplied. Unapproachable value at £7/15/-, or factory built 45/- extra. Carriage 10/-. If required louvred metal cover with 2 carrying handles can be supplied for 17/6.

Where an extra input socket with associated volume control is required for mixing purposes this can be provided for 13/- extra.

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3-speed mixer autochangers B.S.R., £7/19/6. Collaro £9/9/- (5/- ea.).
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Collaro mixer changer in cream carrying case £12/19/6 (6/-).
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Silvered mica condensers pref. values to 1500 pf. 6d., to 8200 pf. 1/-.
Resistors 20% tol. pref. values ½ W. 3d., 2/6 doz. ½ W. 4½d., 4/- doz.
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.1	2500	.....	4/- (1/-)
.2	2500	.....	10/- (1/6)
.5	6 K.V.	.....	10/- (3/-)

P.M. SPEAKERS

2-3 ohm. Post 2/6 one, 3/- two.
5in. 15/6, 6½in. 17/6, 8in. 19/-, 10in. 22/6.

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500 v. .001, .002, .005, .01 mf., 7½d. ea.
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32	T	275	.....	1/9
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All values.

Long spindleless switch	2/3
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SPECIAL OFFER:

200 kc. DT cut, zero temperature coefficient over the range −30° centigrade to +85° centigrade. Frequency adjustment .002% or better. Mode: Face shear. Silver-plated electrode, wire mounted. Basing ¼in. pin spaced. Other bases to order. £1 each.

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POWER PRESSWORK to 250 ton capacity, including Hydraulic
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1A8GT	10/-	6H6GT	4/-	25A6G	10/-	EF54	8/-
1H5GT	10/-	6H6M	5/-	25Z5	8/6	EL32	7/6
1N5GT	10/-	6K8GT	9/-	25Z6GT	8/6	GU50	12/6
1C5GT	10/-	6L6G	10/-	35Z4GT	8/6	KTW61	7/6
1Q5GT	10/-	10/-	6L6M	35Z5GT	8/6	KTW62	7/6
1L4	7/6	6L7M	8/6	35L6GT	8/6	KTW63	7/6
1LN5	7/6	6N7GT	7/6	50L6GT	8/6	KT33C	10/-
1LD5	7/6	6Q7GT	8/6	50B5	10/-	KT61	10/-
2X2	5/-	6S7M	8/6	50C5	10/-	KT66	12/6
3A4	9/-	6U7G	8/6	42	8/6	KT2	5/-
3Q4	9/-	6907M	10/-	45	10/-	PEN25	6/6
3V4	7/6	6887M	7/6	75	8/6	PEN46	7/6
384	7/6	6S67M	6/6	80	8/6	QP25	6/6
3Q5GT	10/-	6X5GT	8/6	807E	7/6	QP21	8/-
5U4G	8/6	6S17	6/6	807USA	10/-	QP230	8/-
5Y3GT	8/6	6S8A7	8/6	803	35/-	SP61	4/-
5Z3	8/6	6S9GT	8/6	805	35/-	SP41	4/-
5Z4G	8/6	6S8N7GT	9/-	813	105/-	TP23	8/-
6A7G	8/6	6S17GT	9/-	866A	12/6	TH233	10/-
6A6	10/-	6S7J	8/6	872A	21/-	U17	5/-
6C6	6/6	6S8K7	7/6	9001/2/3	6/-	U19	10/-
6D6	6/6	7C5	8/6	9004	6/-	U22	8/6
6AC7	6/6	7A7	8/6	9006	5/-	U32	8/6
6AG7	10/-	7C7	8/6	954	5/-	VP23	6/6
6B8	7/6	7H7	8/6	956/7	6/-	VP41	7/6
6C4	7/6	7S7	8/6	1299A	4/6	VU133	4/-
6C9M	5/-	7S7	10/-	ATP4	4/-	VU120A	4/-
6J5GT	5/-	8D2	4/-	CV66	5/-	VT501	7/6
6J5M	5/-	9D2	4/-	CK510AX	5/-	VR105/30	8/6
6AM6	9/-	4D1	4/-	D1	5/-	VR150/30	8/6
6AQ5	7/6	12A6	7/6	D41	5/-	STV/280/40	15/-
6BA6	8/6	12C8GT	7/6	D42	5/-	S130	7/6
6AT6	9/-	12H6	7/6	D63	5/-	VS70 (7475)	7/6
6F8G	7/6	12K7GT	8/6	EA50	2/-	XH (2 v)	4/-
6BE6	10/-	12AH7GT	8/6	EB34	3/6	XP (1.4 v)	4/-
6V6G	7/6	12K8GT	8/6	EBC33	6/6	Y63	8/6
6V6GT	7/6	12Q7GT	8/6	EF36	6/6	TZ40	35/-
6V6M	10/-	12SA7GT	8/6	EF39	6/6	R3	8/6
6J6	9/-	12SQ7GT	8/6	ECH35	12/6	OZ4	7/-
6AK5	9/-	12SG7	8/6	8P13C	4/-	OZ4A	7/-
6U5G	7/6	12SH7GT	7/6	VP13C	4/-		

OBSOLETE TYPES (Available from Stock)

LP2	3/6	VP2B	8/6	MS/PEN	7/6	354V	5/-
210LF	3/6	TP23	8/-	U10	8/6	ML4	7/6
P2	4/-	TDD2A	8/6	GL446A	25/-	MU14	8/6
2J38G	4/-	PT4/500	10/-	428PT	6/-	MH4	5/-
VP2	8/6	PC13B/C	10/-	PEN DD4020		GL446B	25/-
8P2	8/6	PC13C	10/-		12/6		

LATEST TYPES NOW IN STOCK

EBC41	10/-	RAB/C80	10/-	12AT6	8/-	PAB/C80	15/-
EY51	12/-	B/C85	10/-	12AT7	9/-	6AU6	9/6
EF41	11/-	EF80	10/-	12AU6	9/-	117Z3	8/6
EL41	11/-	B/CL80	12/6	12BA6	9/-	12AX7	10/-
EZ40	10/-	PL81	12/6	12BE6	10/-	DK96	10/-
EM34	10/-	PL82	10/-	12AH8	12/6	DL96	10/-
UL41	11/-	PY81	10/-	35W4	8/6	DAF96	10/-
UY41	11/-	EM80	10/-	PCF80	15/-	DF96	10/-
UF41	11/-	6X4	8/-	EBF80	11/6	ECC84	15/-
UCH42	12/6	PY82	10/-	EF85	10/6	6AQ5	10/-
UBC41	10/-	PC/C84	12/6	EF89	10/-	PCL82	12/6
UAF42	10/-	PCF82	12/6	EUF82	15/-	ECH42	12/6
EF80	10/6	12AU7	9/-				

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1A7GT, 1N5GT, 1R5GT, 1A5GT (or 1950T or 3Q5GT) ..... 40/- Set
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6K8G, 6K7G, 6Q7G, 5Z4G, 6V6G ..... 37/6 "
(1R5, 1S5, 1T4, 1S4 or 1S4 or 3V4) ..... 27/6 "
DK96, DF96, DAF96, DL96 ..... 35/- "
6K8G, 6K7G, 6Q7G, 25A6G, 25Z5 (or 25Z6G) ..... 37/6 "
12K8GT, 12K7GT, 12Q7GT, 35Z4GT, 35L6GT (or 50L6GT). 37/6 "
12SA7GT, 12SK7GT, 12SQ7GT, 35Z4GT, 35L6GT or 50L6GT 37/6 "

NEON INDICATOR, striking at 80 volts. Bayonet fitting, ... 2/-
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Type FT243 Fundamental Frequencies
2 pin ½ inch Spacing.
120 Types: **5675 Kc/s to 8650 Kc/s** (Channel 270/389)
(In Steps of 25 Kc/s.)
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BRAND NEW AND GUARANTEED 10/- each
Complete Sets of 80 and 120 Crystals available.

FT241A CRYSTALS

54th HARMONIC
2 Pin ½ inch Spacing

Mc/s	Mc/s	Mc/s
21.1	22.8	26.0
21.2	22.9	26.1
21.4	23.2	26.4
21.5	23.4	27.0
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BRAND NEW AND GUARANTEED 7/6 each
Complete Sets of 80 Crystals Channel 0/79 available.

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200 Kc/s **10/-** each.
CRYSTAL HOLDERS 1/3 each.
10% Discount on all orders of £5.

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High Speed Vacuum tester, 200-250 A.C. £10 10 0

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G.P.O. Telephone Handset (Press/Talk switch in handle) 25/-

MINIATURE TRANSMITTING STRIP "TYPE 81"

Size 7½in. × 6in. × 3in. Complete with Valves Type CV415, CV309, 2-6AM6, 2-7D9 and Quartz Crystal 4,860 kc/s. Fully wired with circuit.
24/10/- complete.

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Brand new miniature I.F. Strip size 10½in. × 2½in. × 3in. high. Valve line-up: 2-EF92, 3-EF91 and EB91. With circuit.
Price (less valves) 7/6 p. & p. 1/6.
This I.F. Strip is part of above equipment.

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Complete with 3BP1 C/R tube and screen. 7 valves—2-6SN7GT, 2-6H6GT, 6G6, 2X2. 6X5G, volume controls, condensers, etc. Ideal for portable 'scope. In black crackle case size 15½in. × 9in. × 9in. BRAND NEW. **65/-**, carr. FREE.

TRANSMITTER RECEIVER "38" WALKIE TALKIE SETS

Special offer of above set, complete with 5 valves, 4-ARP12 and ATP4, with circuit. Range 7.4 to 8 Mc/s. These sets are not guaranteed but are serviceable.
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Junction box 2/6 extra.

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Containing VCR97 with Mu-Metal Screen 21 valves: 12-EF50, 4-SP61, 2-EA50, 2-EB34. Plus Pots., Switches, H.V. Cond., Resistors, Muirhead S/M. Dial, Double Deck Chassis and Crystal. BRAND NEW ORIGINAL CASES. **67/6.** Carr. 7/6.

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Size 15in. × 8in. × 2in. Complete with 45 Mc/s. Pye Strip, 13 valves, 10 EF50, EB34 and EA50, volume controls, and bosts of Resistors and Condensers. New condition. Modification data supplied.
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Unit contains VCR517 Cathode Ray 6in. tube, complete with Mu-Metal screen, 3 EF50, 4SP61, and 1 5U4G valves, 9 wire-wound volume controls and quantity of resistors and condensers. Offered BRAND NEW (less relay) at **67/6.** Plus 7/6 carr. "Radio-Constructor" 'scope circuit included.

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VCR139A. 2½in. C/R Tube. Brand new in original cartons (carr. free) £1 15 0
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Very latest type "Monarch" in hammered gold finish. 3-speed with H12P37 crystal turnover pick-up. Plays mixed records. Brand new and guaranteed. Listed at £16/10.
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THE "TELETRON" BAND III CONVERTER

This converter which is built around two valves type EF80 (Z719) is for use with T.R.F. or Superhet Band I Television receivers. Complete set of Teletron coils only, with practical and theoretical wiring diagram **15/-** post free. Chassis measuring 7in. × 3in. × 1¼in., ready drilled to specification, 3/9 plus 9d. packing and post. Alternatively construction details only with separate individually priced parts list, 6d. post paid. The complete kit as specified, including all the above valves, etc., down to the last nut and bolt, can be supplied at **48/6** only, plus 2/- packing and post. Built up and tested **68/6.** Power Pack RH **22/6** extra.

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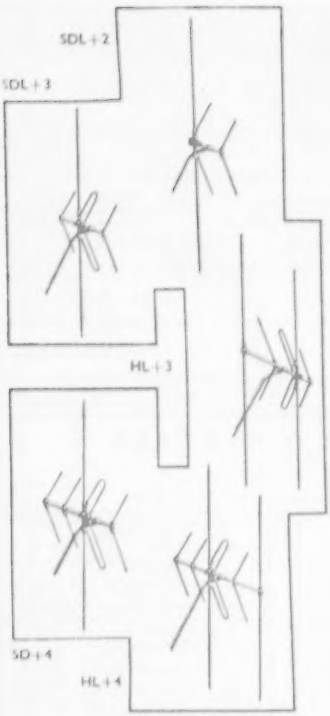
Ideal for Tape Recording, Gramophone Amplifier, etc. Very sensitive. Guaranteed and Tested. 5/- (ex-units), or **8/6** Brand new and boxed.



COMBINED AERIALS

offer many advantages over separate Band I and Band III aerials when used with multi-channel receivers which require only a single input.

They require only one common mounting, and no matching network to combine the two signals, and if correctly designed the Band I section may add to the Band III signal pick up. Both sections may be made directional when the transmitters are reasonably co-sited in relation to the receiving aerial. When directive properties on the Band I section is not required this may comprise a single dipole giving complete freedom of orientation of the Band III section.

The angle given to the Band III elements of the Wolsey combined aerial is designed to take advantage of the fact that a Band I dipole operated at Band III frequencies has a radiation pattern usually comprising four major lobes approximately at the same angle from the horizontal as the elements on the Band III section are disposed with the result that increased pick up is achieved on Band III.

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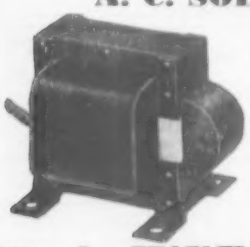

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For Cathode Ray Tubes having Heater/Cathode short circuit or for C.R. Tubes with failing emission.
Type A. Low leakage windings. Ratio 1 : 1.25 giving a 25% boost on Secondary.

2 volt	10/6 each	With Tag
4 volt	10/6 each	Panel and
6.3 volt	10/6 each	Solder Tags
10.8 volt	10/6 each	
13.3 volt	10/6 each	

Ditto with mains primaries 12/6 each.
Type B. Mains input 200/240 volts. Low Capacity. Multi Output 2, 4, 6.3, 7.3, 10 and 13 volts. Input has two taps which increase output volts by 25% and 50% respectively. This transformer is suitable for all Cathode Ray Tubes. With Tag Panel 21/- each.
Type C. Low capacity wound transformer for use with 2 volt Tubes with failing emission. Input 200/240 volts, Output 2-2-[-2-[-2 volts at 2 amps. With Tag Panel 17/6 each.
All Isolation Transformers are individually boxed, labelled and clearly marked with relevant data.
NOTE:—It is essential to use mains primary types with T.V. receivers having series connected heaters.

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HIGH STABILITY. ½ w., 1%, 2/-. All preferred values 100 ohms to 10 meg.

5 watt	WIRE-WOUND RESISTORS	1/3
10 watt	25 ohms—10,000 ohms	1/6
15 watt		2/-

15,000 ohms—50,000 ohms, 5 w., 1/9; 10 w. 2/3

WIRE-WOUND POTS. 2 WATT LAB. COLVERN ETC.

Pre-set Min. T.V. Type Knurled Slotted Knob. All values 25 ohms to 30 K., 3/- ea. 50 K., 4/-. Ditto Carbon Track 50 K. to 2 Meg. 3/-.	Standard Size Pots., 2½in. Spindle High Grade. All Values, 100 ohms to 50 K., 5/6; 100K., 6/6. W.W. EXT. SPEAKER CONTROL 10 Ω 3/-.

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I.F. TRANSFORMERS. 465 kcs. Pye Radio, midget size, 2½in. × ½in. × ½in., 7/6 pr. With data sheet.

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COPPER PLATED AERIAL RODS. ¼ × 12in. push fitting, 3/- doz. Post 1/-.
ALADDIN FORMERS and cores. ½in., 8d., ¾in., 10d. 1in. FORMERS with Case and Core, ½in. sq. × 1½in. and ½in. sq. × 2½in., 2/- ea.
SLOW MOTION DRIVES. Epicyclic ratio 6 : 1, 2/3.
TYANA. Midget Soldering Iron. 200/220 v. or 230/250 v., 14/11.
SOLON MIDGET IRON. 25 w., 22/-.
MIKE TRANSF. Ratio 50 : 1, 3/9 ea., new and boxed.
MAINS DROPPERS. 3 × 1½in. Three Adj. Sliders, 3 amp. 750 ohms, 4/3. 2 amp., 1,000 ohms, 4/3.
LINE CORD. 3 amp., 60 ohms, per foot, 2 amp., 100 ohms per foot, 2 way 6d. per foot, 3 way 7d. per foot.

CRYSTAL MIKE INSERT. Famous make, precision engineered. 45ns only 1½ × 3/16in. Bargain Price, 6/6. No transformer required.

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5in. R.A., 17/6.	7in. × 4in. Goodmans, 21/-.
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6½in. Goodmans, 18/6.	10in. Rola, 30/-.
6½in. ditto w/Trans., 21/-.	12in. Pleasey, 30/-.
8in. M.E. 2.5 k. or 2 k. field, tapped O.P. transf., 24/6.	

CRYSTAL DIODE, G.E.C., 2/-. GEX34 4/-.
CRYSTAL SET CONSTRUCTION, 1/-.
40 CIRCUITS USING GERMANIUM DIODES, 3/-.
H.R. HEADPHONES, 4,000 ohms. Brand new, 17/6 pr.
SWITCH CLEANER Fluid, squirt spout, 3/9 tin.
TWIN GANG TUNING CONDENSERS. .0005 mfd. midget with trimmers 8/6; 375 pf. midget less trimmers 6/6; .0005 Standard size with trimmers and feet 9/-; less trimmers 8/-; ditto, soiled, 2/6.

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2 p. 2-way, 3 p. 2-way, short spindle	2/6
5 p. 4-way, 2 wafer, long spindle	6/6
2 p. 6-way, 4 p. 2-way, 6 p. 3-way, long spindle	5/6
3 p. 4-way, 1 p. 12-way, long spindle	3/6

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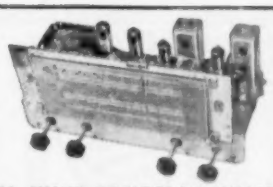

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THREE WAVEBANDS FIVE VALVES
S.W. 16 m.—50 m. LATEST MULLARD
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12 month Guarantee, A.C. 200/250 v. 4-way switch. Short-Medium-Long-Gram. A.V.C. and Negative feedback. 4.2 watts. Chassis 13½in. × 6½in. × 2½in. Glass Dial 10 × 4in., horizontal or vertical available. 2 Pilot Lamps. Four Knobs, Walnut or Ivory, aligned and calibrated. Chassis isolated from mains.

BRAND NEW **£10.10.0** Carr. 4/6.
Matched 3-ohm speakers 8" 19/6, 10" 25/-

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Plessey
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Brand new Plessey 3-speed Autochanger Mixed Unit for 7, 10 and 12in. Records. Twin Hi-Fi Xtal Head with Duopoint sapphire styli. Plays 4,000 records. Sprung mounting. Baseboard required 15½ × 12½in. Height 5½in. Depth 2in. Super Quality. Post free. A.C. 200/260 v.

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Mod. 75 our price **£8-19-6**
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For London, Midland and Northern Transmissions
Suitable for all T.V. makes. T.R.F. or Superhet.
Ready wound coils, two EF80 valves, all components, punched chassis, circuit diagram, wiring plans. COMPLETE KIT for mains operation 200-250 v. A.C. £3 10 -.

AS ABOVE less POWER PACK. Requires 200 v. 20 mA. H.T. 6.3 v. .6 a. L.T. £2 5/-.

Mains Transformer to above Spec. ...	10/6
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Larger chassis for Mains Model ...	4/-
Teletron Coilset with plans ...	15/-
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1T4	9D2	6L6
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3V4	8P61	12K7
5U4	8P41	12K8
6AC7	PEN46	12Q7
6AM6	EF92/W77	25Z4
6AT6	1/6	35L6
6C4	EA50	35Z4
6F12	2/6	EBC41
6J6	2X2	EBF80
6J7	CV6	ECC81
6K8	E1148	ECH35
6SL7	EB34	ECL80
6SN7	3/6	ECH42
6V6GT	5D6	EF41
6U8/Y63	6H6M	Mullard EF50
787	6/6	Mullard EF53
6D9	DET18	EF80
DK91	EL41	
DF91	6AL5	EZ40
DAF91	6G6	KT33C
DL92	6K6	MU14
DL94	6J5	PL81
EBC33	6K7G	PL82
EF50 SYLV.	6SK7	PY82
RED	EB91	U25
EF91	HVR2 (near)	N78
	VR116	KY51

7/6

OZ4, 1A3, 6BE6, 6BW6, 6C6/77, 6D6, 6P6, 6K7GT, 6K7M, 6SA7, 6V6G, 6X4, 6X5, 12AG, 12AX7, 12BA6, 12BE6, 12SD7, 807, EF39, EL32, HVR2A, PEN25, U22, UF41, VP23, V870.

12/6

ECF82	PCC84	PCF80	PCF82

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Full instructions, point to point wiring diagram. Circuit diagram, and full shopping list 1/-. All components may be purchased separately.

Build this Excellent Kit for Yourself !

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Ratio 1-1.25 giving a 25% boost on secondary. Particularly suitable for High Definition Receivers. Four types available to cover most tube heaters.
NR 9A 2 volt ; NR 9B, 4 volt ; NR 9C, 6.3 volt ; NR 9D, 10.8 volt ; NR 9E, 13.3 volt.
With Tag Panel and Solder Tags. 10/6 each.

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Mains input : 220/240 volts.
Multi output : 0-2-4-6.3-7.3-10 and 13 volts.
Input has two taps which increase output volts by 25% and 50% respectively.
This transformer is suitable for most Cathode Ray Tubes in Medium Definition Receivers.
The MOST versatile Low Capacity C.R. Transformer with Universal Output.
With Tag Panel and Solder Tags, 21/- each.

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A most useful transformer for use with 2 volt Tubes with falling emission.
Input : 230/240 volts.
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With 2 valveholders for 954, 955 type of valves	5/-

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K 3/45 ...	8/2	K 3/100 ...	14/8

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4 volt 3 amp.	10/-
6.3 volt ½ amp.	5/-
6.3 volt 3 amp.	9/-
12 volt .75 amp.	5/-

LOUDSPEAKER CABINETS

This attractive walnut finished cabinet is available for 6½in. or 8in. speaker units. Metal speaker fret, complete with back and rubber feet.
6½in. type :
Measures 8½in. x 8½in. x 4½in. at base. Price 16/6 each.
8in. type :
Measures 10½in. x 10½in. x 8in. at base. Price 20/6 each.
Six. type :
Measures 6½in. x 4½in. x 7½in. 16/6

LOUDSPEAKER UNITS, ETC.

	each
5in. Types by Elac., Lectrona, Celestian, etc.	17/6
6½in. Types by Goodmans, Rola, R. & A.	18/6
8in. Types by Goodmans, Plessey, R. & A.	19/6
10in. Types by R. & A. Celestian, etc.	25/6
6½in. Wafer Speaker by Truvox, suitable for Car Radio, etc. ...	20/-
12in. Plessey Lightweight ...	35/-
Eliptical Speakers, Goodmans 4in. x 7 in.	19/6

All above are P.M. Speakers. Standard 2-4 v. Speech Coil.

TELEVISION TABLE

Size of top, 19½in. x 19½in. Height, 18in. Rounded legs which unscrew for transit. 40/- each, carriage 3/-.

CONNECTOR LEADS

Red single lead with wander plug and socket. 4d. each.

WHEN ORDERING PLEASE QUOTE " DEPT. W.W."

ALPHA RADIO SUPPLY CO.

5/6 VINCES CHAMBERS VICTORIA SQUARE LEEDS I.

TERMS : Cash with order or C.O.D. Postage and Packing charges extra, as follows : Orders value 10/- add 9d. ; 20/- add 1/- ; 40/- add 1/6 ; £5 add 2/-; unless otherwise stated. Minimum C.O.D. fee and postage 2/3.

MAIL ORDER ONLY

GEE-RADIO LTD

R.C.A. BRAND NEW 15in. 15 ohms 20 watt P.M. SPEAKERS. Snip price **£9/19/6.** Carriage 12/6.

R.C.A. PRESSURE UNITS. 15 ohms. P.M. 20 watts. Complete with Exponential Horn, length 14in. dia. 17in., **£5/19/6.** Carriage 10/-.

COMMUNICATION RECEIVERS P.C.R. 2 waveband 13-49, 200-600, 800-2,100 metres. Also P.C.R.3. 13-41, 41-120, 200-550 metres. Both types in brand new condition. Fully tested before despatch. Price **£7/10/-** each. Carriage 7/6.

POWER PACKS for the above models available. A.C. mains. Built as for the R1155A and 1132A receivers. **£5.** Carriage 7/6.

R 1155A RECEIVERS. In good condition. **£8/10/-.** Carriage 7/6.

R 1132A RECEIVERS. In good condition. **£3/17/6.** Carriage 7/6.

POWER PACKS for the above, complete with speaker built into very attractive polished 8in. extension speaker cabinet. Ready for use on A.C. mains 200-250 v. **£5/10/-.** Carriage 7/6.

RECEIVER TYPE 109 in good condition. Freq. range 1.8-3.9 Mc/s. and 3.9-8.5 Mc/s. continuous. Operates on 6 v. battery. Price **£4/7/6.** Carriage 10/6.

POWER PACK for the above **£4.** Carriage 5/6.

C.M.G.-25 PHOTO CELLS (Osram). Brand New **17/6** each.

TELE-F. Sound powered telephones with ringing generator. Complete in wooden carrying case. Used but in sound condition. **37/6.** Carriage 3/6.

50 WATT EX GOVT. AMPLIFIER with 4-KT66's in paralleled push-pull. Standard 200-250 v. A.C. input. Output imped. 600 ohms. Line. High imp. gram and mike input. Bass boost control fitted. Quality amplifier housed in strong metal case ready for use. Terrific performance. Bargain price **£25.** Carriage extra.

METERS
0-1 mA. 2½in. round flush mounting. **21/-.**
0-10 mA. 2½in. round flush mounting. **12/6.**
0-5 amp. 2in. square flush mounting. **15/-.**
1-0-1 milli-ammeters, flush mounting 4in. scale. **45/-.**
0-300 v. A.C. flush mounting 2½in. scale. **28/-.**
0-25 amp. D.C. flush mounting 2½in. scale. **12/6.**
0-15 v. and 0-250 v. D.C. pocket volt-meter 2½in. **15/-.**
AR-77 "5" meters 2in. F.S.D. 5 mA. **30/-.**
0-200 v A.C. meters flush mounting 3½in. Grade 1. **40/-.**

WAVEMETER CLASS D. Freq. band 1,900 kc/s-8,000 kc/s. (158-37.5 m.) in two ranges, 1,900 kc/s-4,000 kc/s. Also 4,000 kc/s-8,000 kc/s. in perfect working order. Supply 6 v. D.C. input. **£8/5/-.** Carr. paid.
CONDENSERS. 2 mfd. 7.5 kv. wkg. at 15 kv. test (Dubilier). Brand new in original crates. **£2/10/-.** Carriage 5/-.

VARIABLE VOLTAGE REGULATOR TRANS. Input 230 v. A.C. at 21 amps. Output 57.5 volts in 16 equal steps to 230 v. at 21 amps. Ex. Govt. in perfect condition. **£12/10/-.** Carr. extra.

H-DUTY TRANSFORMERS L.T. 230 v. PRI-11-12.5 v. SEC. at 70 amps. **£5/10/-.** Carriage 7/6.

DON "8" TWIN TELEPHONE CABLE on 1 mile and ½ mile drums. **£5** per mile, **25/-** per ½ mile. Carriage extra.

"AVO" MODEL 7. In perfect condition with leads and batteries (cases available). **£13/10/-.** Post 3/6.

WESTON BATTERY OSCILLATORS. Model E 692 Type 2. In perfect condition. Coverage 100 kc/s-20 Mc/s. Audio output approx. 400 c/s. Complete with instruction books and charts. **£5/19/6.** P.P. 4/6.

COLLINS RADIO RECEIVERS TYPE 46159A. Freq. range 1,500-12,000 kc/s. Input 12 v. or 220 v. D.C. Less crystal and power pack. This unit is part of TCS-12-Trans. Receiver equipment. In clean and good condition. Limited quantity. **£15.** Carriage 7/6.

RECORD MEGGERS. 0-500 v. 0-20 meg. with carrying case. **£8/5/-.** Post paid.

VALVE TESTER (by Radio City Products, U.S.A.). Model No. 314. Brand new, unused with instruction manual. 110-220 v. A.C. 50 c/s. Will test most American valves from 1.1 v. to 200 v. **£10.** Carr. 5/-.

AMERICAN DYNAMOTOR TYPE P.E. 103A. Heavy duty power supply. Input 6 v. @ 21 amps. or 12 v. @ 11 amps. Output 500 v. @ 16 amps. Rating continuous. Complete with connection cable and mounting rack in new and unused condition. Sealed in original crates. **£15.** Carriage extra.

ROTATABLE LOOP AERIALS (BENDIX) TYPE MN. 24 c. (motor driven). 18in. loop. New and unused. **£3/15/-.** Carr. 5/-.

R.C.A. PRE-AMPLIFIERS. Comprising 2 6J7 valves and connections. Available for photo cell input 250 v. H.T. 6.3 v. L.T. supply required. Output control. Complete unit. New and unused. **£5.** Carriage paid.
24 v. D.C.-230 v. A.C. 50 CYCLES. ROTARY CONVERTERS. 120 watts output. Brand new. **£4/17/6.** Carr. 7/6.

RACKS. G.P.O. STANDARD. For 19in. panels. Steel channel sides, correctly drilled, heavy angle base, height 6ft. **£3/15/-.** Carr. extra.

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MAINS TRANSFORMERS

Primary, 200-250 v. P. & P. 2/-. 350-0-350, 100 mA, 6 v. 3 amp., 5 v. 2 amp., **22/6**.

Semi-shrouded drop-through 350-0-350 v., 120 mA., 6.3 v. 4 amp., 5 v. 2.5 amp., **22/6**.

Drop thro' 350-0-350 v. 70 mA. 6 v. 2.5 amp. 5 v. 2 amp., **14/6**.

Chassis mounting or drop-thro'. Pri. 110-150 v., Sec. 350-0-350, 250 mA., 6.3 v. 7 amp., 6.3 v. 0.5 amp., 5 v. C.T., 6.5 amp. 4 v. 4 amp. P. & P. 3/6. **32/6**.

Chassis mounted and fully shrouded, 80 mA., 6. v. 3 amp., 5 v. 2 amp., **14/6**.

Drop thro' 270-0-270 60 mA., 6 v. 3 amp., **11/6**.

250 v. 350 mA., 6.3 v. 4 a., twice 2 v. 2 a., **19/6**.

Auto-trans. Output 200-250 H.T. 500 v. 250 mA., 6 v. 4 a., twice, 2 v. 2 a., **19/6**.

Auto-trans. Input 200-250. H.T. 350 v. 350 mA. Separate L.T. 6.3 v. 7 a., 6.3 v. 1½ amp., 5 v. 3 amp., **25/-**. P. & P. 3/-.

Mains Transformer, fully impregnated. Input 210, 220, 230, 240. Sec. 350-0-350 100 mA., with separate heater transformer. Pri. 210, 220, 230, 240. Sec. 6.3 v. 2 amp., 6.3 v. 3 amp., 4 v. 6 amp. and 5 v. 2 amp., **30/-**. P. & P. 5/-.

350-0-350 75 mA. 6.3 v. 3 a. tap 4 v. 6.3 v. 1 a., **13/6**.

500-0-500 125 mA. 4 v. C.T. 4 a., 4 v. C.T. 4 a., 4 v. C.T. 2.5 a., **27/6**.

500-0-500 250 mA. 4 v. C.T. 4 a., 4 v. C.T. 5 a., 4v. C.T. 4 a., **39/6**.

6½in. M.E. Speaker, 1,000 ohm field, **15/-**.

R. & T.V. energised 6½in. speaker with O.P. trans. field coil. 175 ohm **9/6**. P. & P. 2/6.

R. & A. 6½in. M.E. speaker, with O.P. trans. field 440 ohms, **10/6**. P. & P. 2/6.

Volume Controls. Long spindles, less switch, 50K, 500K, 1 meg., **2/6** each. P. & P. 3d. each.

Volume Controls. Long spindle and switch, ½, ¼, 1 and 2 meg., **4/-** each. 10K and 50K **3/6** each. ¼ and 1 meg., long spindle, double pole switch, miniature, **5/-**. P. & P. 3d. each.

Trimmers, 5-40 pf., **5d.**. 10-110, 10-250, 10-450 pf., **10d.**

Twin Gang .0005 Tuning Condenser **5/-**. With trimmers **7/6**.

Twin Gang .0005, with feet, size 3½ × 2 × 1¼in., **6/6**.
3-gang .0005, with feet, size 4½ × 3 × 1¼in., **7/6**.

T.V. Coils, moulded former, iron-cored wound for re-winding purposes only. All-can 1½ × 1¼in., **1/-** each, 2 iron-core. All-can 2½ × 1¼in., **1/6** each. The above coil formers are suitable for the "Wireless World" F.M. tuner.

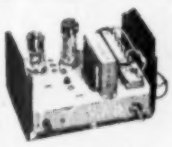
Used Metal Rectifier, 250 v. 150 mA., **6/6**. **Metal Rectifier**, 250 v. 45 mA., **6/-**.

Metal Rectifier, RM2 125 v. 100 mA., **3/6**.

OUTPUT TRANSFORMERS

Standard type 5,000 ohms imp., **4/9**. 42-1 with extra feed-back windings, **4/3**. Miniature 42-1, **3/3**. Multi-ratio 3,500, 7000 and 14,000, **5/6**. 10-watt push-pull, 6V6 matching **7/-**. 99-1 ohm speech coil, **6/6**.

T.V. CONVERTER



For the new commercial stations, complete with 2 valves. Frequency can be set to any channel within the 186-196 Mc/s band. I.F. will work into any existing T.V. receiver between 42-68 Mc/s. Input arranged for 80 ohm feeder, EF80 as RF amplifier, ECC81 as local oscillator and mixer. The gain of the first stage, R.F. amplifier 100B. Required power supply of 200 D.C. at 25 mA., 6.3 v. A.C. at 0.6 amp. Input filter ensuring freedom from unwanted signals. Simple adjustments only, no instruments required for trimming. Will work into T.R.F. or superhet, Band Switch and wire wound gain control. Fully screened in black crackle finished case, size 5¼in. long, 3¼in. wide, max. overall height 4¼in. **£2/19/6**. P. & P. 2/6. As above, complete with built-in power supply A.C. mains 200-250 v. **£3/19/6**. Post & Packing 2/6.

BAND III CONVERTER KIT

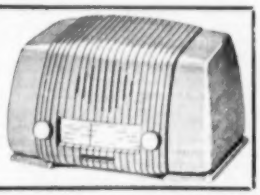
comprising 5 channel tuner, mains transformer, metal rectifier, electrolytic, 2 valves 12AT7 and EF80 and all necessary components for A.C. mains operation. Complete with conversion data **£2/5/-**. P. & P. 2/6.

R.S.R. MONARCH three speed automatic changer, current model. Brand new. Will take 7in., 10in., or 12in. records mixed. Turnover crystal head. A.C. mains 200-250. Pre-Budget Price while stocks last. **£7/15/-**. P. & P. 3/-

P.M. SPEAKER. 6½in. closed field **19/6**. 8in. closed field **20/6**. 10in. closed field **25/-**. 34in. **16/6**. 12in. closed field **35/-**. P. & P. on each 2/-.

EXTENSION SPEAKER in polished walnut, complete with 8in. P.M. P. & P. 3/-. **24/6**.

T.R.F. KIT
IN PLASTIC CABINET



3 valve plus metal rectifier, A.C. mains 200-250 v. Medium and long waves. In pastel blue or brown. Valve line-up: 2 VR65S and VT52. Size 15½in. long by 9in. high by 7in. deep. **£3/19/6**. P. & P. 4/6.

CABINET complete with chassis, back plate, 2 wave band scale, drum pointer, spring, drive spindle, 3 knobs and back and 5in. speaker with O.P trans. **£2**. P. & P. 4/6.

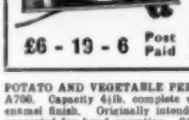
1,000ft. High Impedance Recording Tape on aluminium spool. **12/6** post paid.
SPECIAL OFFER. 6in. P.M. speakers, removed from chassis, fully guaranteed. All by famous manufacturers. P. & P. 1/6. **12/6**.

16 in. TUBE
BY FAMOUS MANUFACTURER

Brand new E.H.T. 14 Kv. Heater. 6.3 volts 0.6 amp., guaranteed 3 months. **29/19/6** post, packing and insurance 22/6. H.P. terms available. E.H.T. and scanning components available.

20-WATT A.C. or D.C. 200-250 v. **FLUORESCENT KIT** comprising trough in white stove enamel finish, two tube holders, starter and holder and barreter. Post and packing 1/6. **12/6**

POLISHING ATTACHMENT for electric drills. Quarter inch spindle, chromium plated 5in. brush, 3 polishing cloths and one sheepskin mop mounted on a 3in. rubber cup. Post and pkg. 1/6. **12/6**. Spare sheepskin mops **2/6** each.



3-speed TRANSCRIPTION MOTOR
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£6 - 19 - 6 Post Paid

Complete kit of parts comprising accurately balanced precision made heavy turntable with rubber mat, large constant speed condenser starting motor, base plate. Can be assembled in half an hour. A.C. Mains 200/250v. Fully guaranteed. Parts sold separately.

POTATO AND VEGETABLE PEELER. By famous manufacturer. To suit models A200 and A700. Capacity 4½lb. complete with water pump. All aluminium construction, white stove enamel finish. Originally intended for adaptation on an electric food mixer can be easily converted for hand operation. 39/6. P. & P. 3/-

STANDARD WAVE CHANGE SWITCHES. 4-pole, 3-way **1/9**. 3-pole, 3-way **1/9**. 3-pole 3-way **1/9**. 9-pole 3-way **3/6**. Miniature type, long spindle, 3-pole, 4-way, 4-pole 3-way and 4-pole 2-way **2/6** each. 2-pole 11-way, twin wafer **5/-**. 1-pole 12-way single wafer **5/-**. P. & P. 3d.

Ion Traps for Mullard or English Electric tubes **5/-** post paid.
Standard 465 Kc. iron-cored I.F.s, 4 × 1½ × 1½in. per pr., **7/6**. Wearite standard, iron-cored 465 Kc., I.F.s., 3½ × 1½ × 1½in., per pr., **9/6**.
Iron-cored **465 Kc.** Whistle Filter **2/6**.

465 Kc. MIDGET I.F.s. Q-120 size 1½in. long, 1in. wide, ½in. deep by very famous manufacturer. Pre-aligned adjustable iron-dust cores, per pair, **12/6**.

3-speed automatic changer by famous manufacturer. 10 Records, turnover crystal head, brand new, current model. A.C. mains 200/250v. (list price £14-10), **£8-19-6**. P. & P. 5/-.

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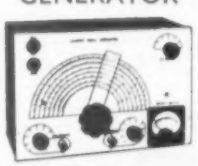

Coverage 120 Kc/s-84 Mc/s

A.C. Mains 200/250 v. **£4 - 19 - 6**

Or 34/- deposit, 3 payments o. 25/-. P. & P. 4/6 extra

Mains Droppers, 0.3 amps., 460 ohms tapped 280 and 440, **1/6**. 0.3 amp., 717 ohms, tapped at 160 ohms, vitreous, **1/6**. 0.3 amps. 950 ohms, tapped 700 and 825, **2/6**. 0.2 amp., 1,000 ohms, vitreous, tapped, **2/6**. vitreous, 0.3 amp., 700 tapped 680, 640, 600, **2/6**. P. & P. on each 3d.
T.V. Width Controls 3/6.

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6in. Enlarger **17/6**. 12in. **27/6**.
Germanium Crystal Diode 1/6. post paid. **Used 9in. Tube** with ion burn **17/6**. Post paid.
Line O.P. Transformer in aluminium can mounted in rubber, **12/6**.
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Scan coils, low line low impedance frame, complete with frame transformer to match above, **27/6**. P. & P. 2/-.
Line and E.H.T. Transformer, 9 Kv., ferrocart core, EY51, heater winding, complete with scan coils and frame output transformer, and line and width control, **35/-**. P. & P. 3/-.
As above, but complete with line and frame blocking transformers, 5 Henry 25 mA. choke, 100 mfd. and 150 mfd. 250 wkg. 380 mA. A.C. ripple. **£2/9/6**. P. & P. 3/-.
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32 mfd. 350 wkg.	2/-
16 × 24, 350 wkg.	4/-
4 mfd., 200 wkg.	1/3
16 × 8 mfd., 500 wkg.	4/6
16 × 16 mfd., 500 wkg.	5/9
16 × 16 mfd., 450 wkg.	3/9
32 × 32 mfd., 350 wkg.	4/-
25 mfd., 25 wkg.	1/6
250 mfd., 12 v. wkg.	1/-
16 mfd., 500 wkg., wire ends	3/3
8 mfd., 500 v. wkg., wire ends	2/6
8 mfd., 350 v. wkg., tag ends	1/6
50 mfd., 25 v. wkg., wire ends	1/9
100 mfd., 350 wkg.	4/-
100 mfd., 450 v. wkg., 280 mA. A.C. ripple	3/11
150 mfd., 350 v. wkg., 230 mA. A.C. ripple	4/6
200 mfd., 275 wkg.	7/6
16 × 16 mfd., 350 wkg.	3/3
50 mfd., 180 wkg.	1/9
65 mfd., 220 wkg.	1/6
8 mfd., 150 wkg.	1/6
60 × 100 mfd., 280 wkg.	7/6
50 mfd., 12 wkg.	1/6
50 mfd., 50 wkg.	2/-

Miniature wire ends moulded, 100 pf., 500 pf., and 001, each **7d.**
Combined 15in. mask and escutcheon in lightly tinted Perspex. New aspect edged in brown. Fits on front of cabinet. **12/6**. As above for 15in. tube, **17/6**.
Frame Oscillator Blocking Trans. **5/6**.
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CHOKES:

5-20 Hen., 150 mA., **15/-**. P. & P. 3/-. 6 Hen. 275 mA., **15/-**. P. & P. 3/-. 100 Hen., 40 mA., **15/-**. P. & P. 3/-. 250 mA., 10 henry, **17/6**. 5 henry 250 mA. 60 ohms, **8/6**.

Wide Angle P.M. Focus Units. Vernier adj. static tube, **15/-**.
P.M. Focus Unit for Mullard tubes with vernier adjustment. P. & P. 2/-. **15/-**.
Energised Focus Coil, ow resistance mounting bracket, **17/1**

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23 HIGH STREET, ACTON, LONDON, W.3

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Terms of Business: Cash with order. Despatch of goods within 3 days from receipt of order. Where post and packing charge is not stated please add 1/6 up to 10/-, 2/- up to £1, and 2/6 up to £2. All enquiries S.A.E., lists 5d. each.

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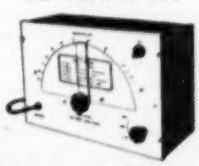

Coverage 40 Mc/s-70 Mc/s

A.C. Mains 200/250 v. **£3 - 19 - 6**

Or 20/- deposit, 3 payments of £1 P. & P. 4/6 extra.

BUILD ONE OF THESE RADIOS NOW

Total building cost £5/7/6 including choice of beautiful walnut veneered cabinet or ivory or brown bakelite. **This is the lowest possible price consistent with high quality. No radio knowledge whatever needed . . . can be built by anyone in 5-5 hours,** using our very simple, easy-to-follow diagrams. This terrific new circuit covers all Medium and Long Waves with optional negative feedback, has razor-edge selectivity, and exceptionally good tone. Price also includes ready drilled and punched chassis, set of simple, easy-to-follow plans—in fact, everything! All parts sparkling brand-new—no junk! **Every single part tested before despatching.** Uses standard octal-base valves: 6K7G high-frequency pentode feeding into 6J5G anode-bend detector triode, coupled to 6V6G powerful output beam-power tetrode, fed by robust rectifier. For A.C. Mains, 200-250 Volts (low running costs—approximately 18 Watts). Size 12in. × 6in. × 9in. Cost of all parts and set of plans £5/7/6 (plus 3/6 for packing and post). C.O.D. 1/6 extra. Priced Parts lists 2/-.

£5.7.6

Build this exceptionally sensitive twin-triode radio. Uses unique assembly system and can be built by anyone **without any radio knowledge whatever in 45 minutes.** Handsome black-crackle steel case with specially made black and gold dial with stations printed. Size of radio only 6¼in. × 5in. × 3in. Covers all Medium and Long waves—uses one only "Ever-Ready" all-dry battery which lasts many months, as H.T. consumption is only 1 to 1.5 mA. Ideal for Bedroom, Garden, Holidays, etc. **Many unsolicited testimonials.** Mr. Woods of Boston, Writes: "I am quite pleased with the little set I purchased from you. I can get the "Home," "Regionals," "A.F.N." and lots of Foreign Stations. I am very satisfied—it is worth every penny of the price." Cost of all parts, plans—everything down to last nut and bolt, 49/6 including post, packing, etc., or send 2/- for priced parts list. Note: We stock complete range of components and valves. *Orders despatched by return.* Mail Order Only.

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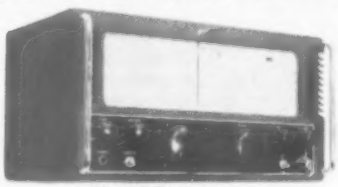

Model 840A illustrated

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840A	£55 0 0	£27 10 0	£2 11 0
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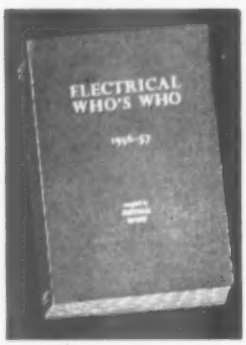

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MODEL MI—11220

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★ **Power output 12 watts at 5-7.5-15-600Ω.**
★ **Valve line-up, 2 of 6L6, 4 of 6J7, 1 of 5U4.**
★ **Tapped transformer for use on 190-250 volts A.C.**
★ **Grey crackled case, size 17 × 11 × 9in.**

CIRCUIT SUPPLIED. **ONLY £9.19.6**

(LESS VALVES, AS SHIPPED BY MAKERS)
SET OF VALVES, NEW, BOXED, **59/6.**

POWER UNIT 247

Enclosed in grey steel case, size 11in. x 9¼in. x 7¼in., with chrome handles. For 230 volts 50 cycles mains operation. Output 600 volts 200 mA., fully smoothed by 1,000 volt working paper condensers and extra heavy duty choke. Also 6.3 volt 3 amps. A complete power unit, including 5U4G rectifier and indicator light for only **47/6.** New and in transit case. THIS IS A REAL SNIP.

HIGH VOLTAGE POWER PACKS, ex-U.S.A. Brand new. Input 115 volts A.C., output 1,000 volts at 250 mA. Brand new, complete with two 1616 valves, and 1 spare 1616 double choke and paper smoothing. **£5/5/-.**

TR-50-XM TRANSMITTER—RECEIVERS. 1.5 to 12 Mc/s. Separate Tx and Rx fitted in one cabinet, size 22in. high x 20in. wide x 14in. Wt. 130lb. V.F.O. and 5 crystal positions. Ideal for marine use. Super job, price **£45.**

METER BARGAINS

RANGE	TYPE	SIZE		PRICE
50 Microamp.	D.C. M/C	2½in.	Flush circular, scaled 0-100	59/6
100 Microamp.	D.C. M/C	2½in.	Flush circular, scaled 0-1,500	59/6
500 Microamp.	D.C. M/C	2in.	Flush square, Weston	27/6
500-0-500 Microamp.	D.C. M/C	2½in.	Flush circular, scaled 100-0-100 V.	25/-
1 Milliamp.	D.C. M/C	2in.	Flush square, Fe/NFe	22/6
10 Milliamp.	D.C. M/C	2in.	Flush circular, blank scale	10/6
100 Milliamp.	D.C. M/C	2½in.	Flush circular	10/6
150 Milliamp.	D.C. M/C	2in.	Flush square	7/6
200 Milliamp.	D.C. M/C	2½in.	Flush circular	10/6
1 Amp.	Thermo-couple	2½in.	Projecting circular	6/9
4 Amp.	Thermo-couple	2in.	Flush square	6/9
20 Amp.	D.C. M/C	2in.	Projecting circular	7/6
30-0-30 Amp.	D.C. M/I	2in.	Proj. circ., metal cased, ear type	5/-
15 Volts	A.C. M/I	2½in.	Flush circular	8/6
300 Volts	A.C. M/I	2½in.	Flush circular	30/-
300 Volts	D.C. M/C	2in.	Flush square	10/6

METER RECTIFIERS. 1 mA. Salford Instruments, **8/6;** 5 mA. Salford Instruments, **6/9;** 2 mA., S.T.C., as used in E.M.I. Output Meter, **5/6.** All are full wave bridge and brand new.

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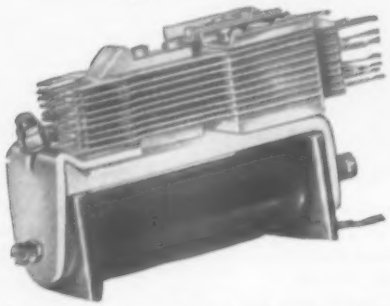

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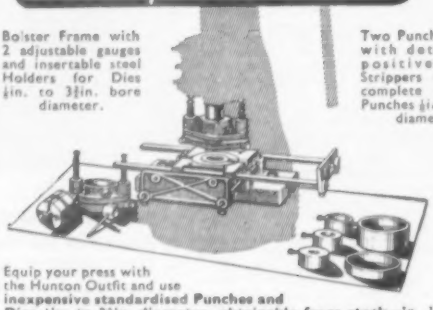

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500 microamps D.C.	2in. Flush square	27/6
1 m.a. D.C.	2in. Flush square	22/6
5 m.a. D.C.	2in. Flush square (scaled 0-100 m.a.)	10/6
10 m.a. D.C.	2½in. Flush circular (blank scale)	10/6
150 m.a. D.C.	2in. Flush square	7/6
200 m.a. D.C.	2½in. Flush circular	12/6
500 m.a. thermo	2in. Proj. circular	5/-
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20 amp. D.C.	2in. Proj. circular	7/6
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CHOKES. 10H 60 mA., **4/-**; 5H 200 mA., **7/6**.

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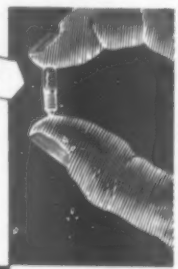

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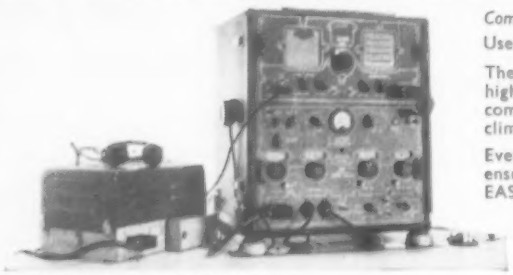

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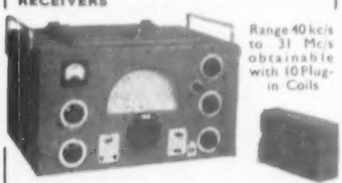

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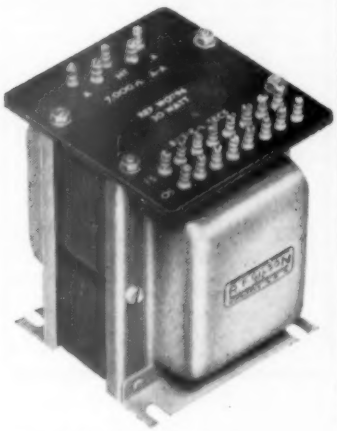

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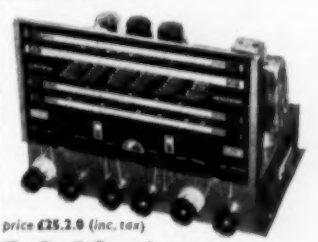

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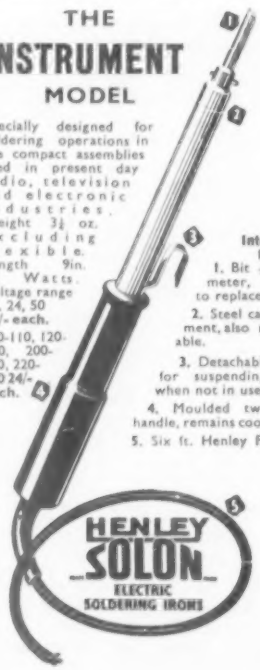

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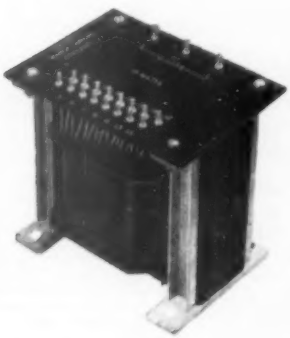

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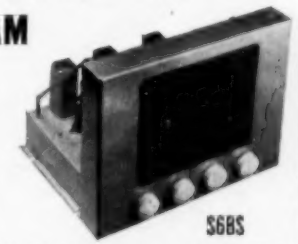

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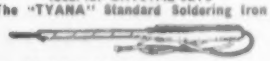

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SENIOR and Junior Electrical and Mechanical Draughtsmen required for the Electronics Drawing Office of the British Thomson-Houston Co., Ltd., Blackbird Rd., Leicester.—Please apply in writing to Chief Draughtsman, Electronics Drawing Office, British Thomson-Houston Co., Ltd., Rugby, giving details of age, experience, etc. [5643

ELECTRONIC test engineer to deal with faults and repair of instruments, mainly in the audio frequency range; good working conditions; pension scheme; excellent recreational, sports and social facilities; modern canteen.—Apply stating age, salary and qualifications, to the Personnel Manager, Muirhead & Co., Ltd., Beckenham, Kent. [5931

WELL-KNOWN company in Croydon area, specializing in industrial instruments and automatic boiler control, requires Mechanical Draughtsman, preferably with experience in industrial instrumentation and production design; high standard of mathematical ability desirable.—Apply, stating age, experience, etc., to P.D.D., Box 1165. [5905

INSTALLATION and Service Engineers required with sound knowledge and experience of mobile and fixed V.H.F. communications equipment; pensionable appointments.—Apply, with details of experience and salary required, to Personnel Officer, British Communications Corporation, Ltd., Exhibition Grounds, Wembley. Wembley 1212. [5922

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ELECTRONIC engineer or Physicist for application research on ultrasonic flaw detector; the post involves contact with industrial users, interesting work and opportunities for advancement in a rapidly expanding field.—Write, giving details of age, experience, qualifications, salary required, etc., to Ultrasonoscope Co. (London), Ltd., Sudbourne Road, London, S.W.2. [5899

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LADY scientist required to act as confidential librarian to company's development staff in Shropshire; science degree essential; opportunities will be afforded for taking part in research work to be undertaken by material suppliers and universities; applications should state qualifications, appointments held, etc.—Write Box BP.968, c/o 191, Gresham House, E.C.2. [5900

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SHIFT chemists (male) required for routine control of production processes in the capacitor field; preliminary period of training will be given, but applicants must be of either Inter. B.Sc. or G.C.E. (Advanced) standard, preferably with analytical experience; applications in person or in writing should be made to The Personnel Manager, The Plessey Co., Kembrey St., Swindon, Wiltshire. [5725

ELECTRONIC development engineers required for work on electronic instruments for medium scale production; University Degree in Electrical Engineering preferred, but H.N.C. or equivalent considered; at least 3 years' experience in industry; age 25-35; salary according to qualifications.—Apply to the Personnel Officer, The Edison Swan Electric Co., Ltd., Ponders End Works, Middx. [5956

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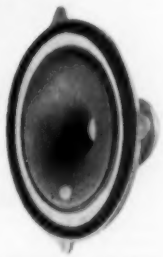

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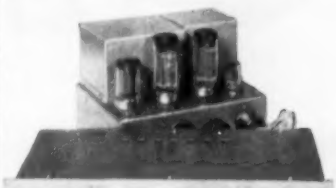

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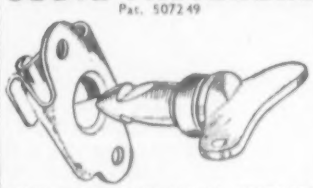

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IMPERIAL CHEMICAL INDUSTRIES, Ltd., Nobel Division, requires for Ardeer Factory, Stevenston, Ayrshire, an electronic technician for maintenance work on large electronic computor: applicants should preferably be of H.N.C. standard and should have had full-time experience in electronics—for example, on radar duties in the Services; candidates keen on this kind of work studying part-time will also be considered.
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DEVELOPMENT engineers required by a company engaged in communications work, Harrow area. Applicants must have sound technical knowledge and preference will be given to those having experience in a similar capacity. Good prospects in a rapidly expanding field. Salary commensurate with experience and ability.—Applications, in writing, to Box No. 627, Sells, Ltd., Brettenham House, Lancaster Place, Strand, W.C.2.

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ELECTRONIC engineers required for permanent appointments, to operate from a service depot being newly established in Manchester for the installation and service of nucleonic instruments and electronic equipment; training will be given at company's main works, to suitable applicants; interviews by arrangement in Manchester.—Write, stating age, experience and qualifications, to Personnel Manager, E. K. Cole, Ltd., Southend-on-Sea. [5889

SENIOR television engineer is required by the Bush Radio laboratories at Plymouth to undertake new and important development work involving visits to the United States; an honours degree in electrical engineering or in physics, or equivalent experience, is essential; the post is permanent and pensionable and will carry a substantial salary.—Apply by letter in the first instance, to the Technical Director, Bush Radio, Ltd., Power Rd., London, W.4. [5891

WIRELESS Operator Mechanics required by Falkland Islands Dependencies Survey for service at isolated British Bases in Antarctic. Must be able transmit and receive morse at 20 words a minute (plain language or code) and be capable elementary maintenance wireless transmitting and receiving equipment. Salary according age in scale £550 rising to £620 a year with all found, including clothing and canteen stores. Keen young men, between 20 and 30 years required preferably single, of good education and high physical standard with genuine interest in polar research and travel willing to spend 30 months under conditions testing character and resource.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/41540/WF. [5946

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RESEARCH Laboratory, C.A.V., Ltd., has a vacancy for an instrument engineer, age up to 30 years, with H.N.C. or equivalent in electronic engineering; required for development and maintenance of electronic apparatus as applied to diesel engine testing and fuel injection development; 5-day week, pensionable, good sports and social facilities.—Write, stating age, experience and salary required, to the Personnel Manager, C.A.V., Ltd., Warple Way, Acton, W.3, quoting Ref. R.22. [5955

ELECTRONIC and transformer manufacturer in Home Counties requires the services of an energetic design engineer; his first duties will be to develop rapid methods of prototype and special small transformer design up to 50kva for sine and pulse operation; for such a man who can also materially assist in electronic engineering projects a fine opportunity exists, with a good salary and working conditions.—Write, giving full details of experience and abilities, present position and salary, etc., to Box 1491. [5950

THE GENERAL ELECTRIC Co., Ltd., Brown's Lane, Allesley, Coventry, requires mechanical development engineers, designer draughtsmen and draughtsmen, preferably with experience of radar-type equipments, for work on guided weapons and like projects; also required, senior and junior electronic development engineers, particularly in the field of microwave and pulse applications; salary according to age, qualifications and experience.—Apply by letter stating age and experience, to the Personnel Manager, Ref. R.G. [0259

AIR MINISTRY require civilian radio technicians at R.A.F. Handforth; applicants should possess sound knowledge of radio and radar; employment, subject to passing entry test, offers good prospects of becoming pensionable, inclusive annual salary £414 at 19 to £551 at 25 and over, rising to maximum of £641; five-day week of 44 hours.—Applications, stating age, qualifications and experience, to Commanding Officer, No. 61 Maintenance Unit (R.T. 11), R.A.F. Handforth, Grove Lane, Cheadle Hulme, Stockport, Cheshire. [5898

WAR DEPARTMENT requires Lecturer at R.E.M.E. Training Centre, Arborfield. Qualifications: Degree in electrical engineering or equivalent; with experience in radio engineering. Salary in accordance with Burnham Technical scale for Assistant B. Starting salary according to qualifications and experience; £115 non-pensionable allowance, Teacher's Superannuation. Full particulars and application forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting Ref. D165/6A. Closing date 12 June, 1956. [5948

BRITISH TELECOMMUNICATIONS RESEARCH, LIMITED, a company associated with A. T. & E. Co., Ltd., and B.I.C.C., Ltd., require a Technical Assistant in their Patents Department. Applicants should have a thorough knowledge of electronics particularly as applied to telecommunications and preferably some experience in patent procedure; the position is permanent and covered by a superannuation scheme, 5-day week.—Applications should be made to the Director of Research, British Telecommunications Research, Ltd., Taplow Court, Taplow, Bucks, giving full details of qualifications, experience and salary required and quoting reference A/12. [5906

ENGINEER required at Ministry of Supply Radar Research Establishment, Malvern, to develop constructional techniques for, and make electrical measurements on, a wide range of transistors and associated semi-conductor devices. Quals.: Higher School Certificate (Science) or equivalent, but possession of a pass degree or H.N.C. in Electrical Engineering may be an advantage. An interest in manipulation of very small structures is essential. Appointment as Experimental Officer (min. age 26) or Assistant E.O. Salary within ranges, E.O. £745–£920; A.E.O. £308 10s (age 18)–£670.—Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King St., London, S.W.1, quoting D158/6A. Closing date June 11, 1956. [5927

ELECTRICAL Engineer or Physicist reqd. by Air Ministry Experimental Establishment in Norfolk for development of airborne radio receiving and transmitting equipments and their associated aerial systems operating mainly on centimetric wavelengths; applicants should have a 1st or 2nd class hons. degree or equiv. in Electrical Engineering or Physics; good physics and electronics background desirable; appointment according to age, experience, etc., as Senior Scientific Officer (min. age 26 with at least 5 years post graduate research experience) or S.O. (min. age 21); salary within ranges, S.S.O. £1,050—£1,185, S.O. £488/10—£885 (superannuable).—Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting A 134/6A; closing date 21 May, 1956. [5909

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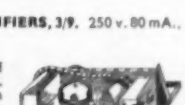

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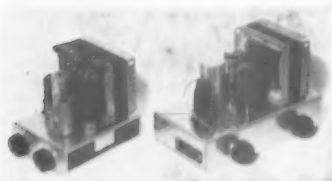

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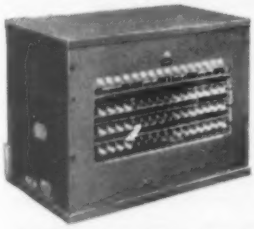

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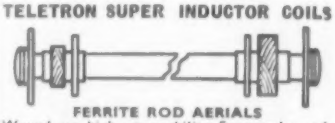

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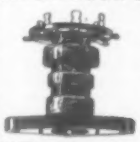

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The bit on the left has been used for making 10,000 soldered joints with Ersin Multicore SAVBIT type 1 alloy. The bit in the centre was used to make 1,000 joints with standard tin/lead alloy. The bit on the right, at the end of its useful life, has made 7,500 joints with standard tin/lead alloy.

7 lb. REELS

Available with Ersin Multicore 5 core Solder in 9 gauges and 6 alloys. Prices on application. Finer gauges supplied on 1 lb. and ½ lb. reels. Precision-made Solid Solder Wire also available.

5/- each (subject)

SIZE 1 CARTON

Available in any of 4 specifications:

Catalogue Ref. No.	Alloy Tin/Lead	S.W.G.	App. l'gth per carton
C 16014	60/40	14	19 feet
C 16018	60/40	18	51 feet
C 14013	40/60	13	17 feet
C 14016	40/60	16	36 feet

BIB RECORDING TAPE SPLICER

For professional and amateur recording tape enthusiasts, this instrument enables tape to be cut and jointed easily, quickly and to extremely fine limits. 18/6 each (subject).

HOME CONSTRUCTOR'S 2/6 PACK

This special pack contains 19 ft. of 18 s.w.g. 60/40 alloy Ersin Multicore Solder wound on a reel. Also containing 40 ft. of 22 s.w.g. 60/40 alloys, recommended for soldering printed circuits. 2/6 each (subject).

BIB SOLDER THERMOMETER

Designed to indicate temperatures of solder in solder baths and on bits, this simple pryometer measures temperatures up to 400°C and is calibrated also in degrees Fahrenheit.

Bib WIRE STRIPPER AND CUTTER

Strips insulation; cuts wire; splits plastic twin flex. A most useful tool for professional and amateur electricians. 3/6 (subject).

MULTICORE SOLDERS LTD., MULTICORE WORKS, HEMEL HEMPSTEAD, HERTS, (BOXMOOR 3636)